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THE THEORY OF RESPIRATION.*

I ASK you to consider with me a topic which is of fundamental interest to physiologists, whether they concern themselves primarily with animals or with plants. I take it the basal identity of the living matter in all organisms and of its metabolism needs neither demonstration nor emphasis at my hands. Nor do I need to lay stress upon the importance of respiration as one of these metabolic phenomena, since it has been recognized from the earliest period as indispensable to life. The phlogiston theory of the composition of the atmosphere had scarcely disappeared below the scientific horizon, before the fact was discovered that there occurs, in animals and in plants alike, an intake of oxygen and an output of carbon dioxide which is intimately related to their existence. This became obvious to man, of course, in his own experience, a very superficial study of the composition of the air inspired and expired from the lungs showing that it had lost oxygen and gained CO_2. This much of respiration was early recognized to occur also with the larger animals, and a few years later like observations were made upon plants by Priestley, and more accurately by Lavoisier and Ingenhouss. Even this knowledge of respiration was not possible before Priestley's discovery of oxygen in 1774, and the very remarkable revolution in chemistry that followed in the closing years of the eighteenth century. Yet

* Address of the retiring president before the Botanical Society of America, Philadelphia, December 28, 1904. Published simultaneously in the *Botanical Gazette*.

this disappearance of oxygen and formation of carbon dioxide are only the external indication of respiration, as has been long recognized.

RESPIRATION IN ANIMALS.

Upon undertaking a special consideration of this topic, I found it needful to examine the recent literature of respiration in animals, the aspect of the general subject with which I felt myself least familiar. I found, to my very great surprise, that animal physiologists have concerned themselves very little with the essential problems of respiration. They seem to have been diverted to the study of the mechanism of gas movements in the higher animals. The lungs, with their intricate structure of lobes, lobules, atria and air 'cells'; the box in which the lungs are located, with its complex muscular mechanism, and the very complicated mechanism of innervation for the voluntary and involuntary movements which it executes; the blood, and the physico-chemical relation of the gases that enter and leave it in the lungs, of those that come into it from the tissues and of those it gives up to the tissues—these are the topics that one finds exploited at length when he turns to the text-books. I diligently examined the most modern and most thorough text-books on animal physiology; such books as Foster's 'Physiology,' Stewart's 'Manual of Physiology,' the 'American Text-book of Physiology' and Schaefer's 'Text-book of Physiology,' but in them I found no treatment whatever, indeed no mention whatever, of the real problems of respiration, that is, of what is happening in the tissues, the processes of which these external phenomena are the sign. Yet this much-studied respiratory mechanism, which is so striking in the higher animals, is entirely wanting in the lower animals and in plants.

Not finding even a clue to the literature in the text-books, it was only after much search that I was able to discover that anything at all had been done; and it is *so* little that it is almost a negligible quantity. There is an obvious reason for this, besides mere interest in the more striking phenomena. I am intending, however, neither arraignment nor excuse, but a bare statement of what were to me rather surprising facts.

RESPIRATION IN PLANTS.

The knowledge of respiration in plants began about the same time—the close of the eighteenth century—and advanced rapidly on account of the notable revolution in chemistry which took place about this time. Ingenhouss, the Dutch naturalist, really ascertained and published in 1779 the chief external facts of respiration; at least he was able to state them essentially as they were known for twenty-five years after his time. In 1804 DeSaussure showed that growth is dependent on respiration; that respiration is more active in growing parts than elsewhere; that it is the cause of the loss of weight to which plants are constantly subject; and later, that the heat set free in flowers is related to the absorption of oxygen. Not until 1833 was respiration treated comprehensively, when Dutrochet expounded the subject, comparing the respiration of animal and plant and showing it to be fundamentally alike in both.

Now at this point there began two remarkable misconceptions. One was the confusion that arose between respiration and the manufacture of carbohydrates, which Dutrochet called 'diurnal respiration.' Of that I shall not speak, save to say that the great weight of Liebig's authority made this error persist for half a century.

RESPIRATION AND COMBUSTION.

The other misconception was engendered by the comparison of respiration to com-

bustion. It had been observed by Lavoisier that the heat of the animal body was dependent upon respiration; the heat of the plant body was shown by DeSaussure to be related to a disappearance of oxygen; combustion consumes oxygen and produces heat; therefore, respiration is a sort of combustion. So the argument ran.

It is quite impossible to overestimate the influence that this conception has had on the study of respiration. The mischief it has wrought depends chiefly, perhaps wholly, upon a misconception of the actual mechanism of combustion, a process that has ever been the *bête noire* of chemistry, as the history of the 'phlogiston' theory well shows. To our changed conceptions of combustion I shall return later.

The idea of combustion, however, which dominated the argument I have cited, was that oxygen combined with carbon to form CO_2 and with hydrogen to form H_2O. It was most natural, therefore, to conceive that the food taken up by the organism stood to it in the same relation as does the fuel to the engine, and that what happens is an actual oxidation of the food immediately and directly; in fact, a process precisely parallel to the burning of the same food outside the body.

One evident outcome of that idea is the current classification of foods into plastic and dynamogenous, those which are useful in building up the body and those that are useful in producing heat within the body; into 'fattening foods' and 'heat-producing' foods. You are doubtless familiar with these phrases.

But if foods are 'burned' in the body it must be important to know how much oxygen enters it, and how much carbon dioxide and water leave it, so as to discern the ratio which exists between them. Plainly a basis for this must be a comparison of the differences between the combustion of foods outside the body and their 'combustion' within the body. Yet, strangely, this has not been made until recently. Without giving the full tables let me show the results arrived at by two observers, regarding two of the most common plant foods, glucose and tartaric acid. These observers assume, you will notice, that the processes are comparable. The results are stated as ratios of CO_2/O_2.

Food.	By combustion.	By respiration.	
		Diakonow.	Purjewicz.
Glucose	$\frac{100}{100}$	$\frac{130}{100}$	$\frac{95}{100}$
Tart. acid	$\frac{160}{100}$	$\frac{290}{100}$	$\frac{162}{100}$

Diakonow's whole series shows that in combustion the carbon dioxid was always less than in respiration; Purjewicz found, with the exception of tartaric acid, and even there the difference between his results and Diakonow's is in the same direction, that it was always greater, his results being absolutely different in significance from Diakonow's. And this is a good type of the results to be found in examining the literature! I am not now concerned in determining which set of results is correct, inasmuch as I believe both are valueless, since on the assumption upon which they are based neither can be interpreted.

RESPIRATORY RATIO.

Long before this sort of comparison was made, however, a voluminous literature arose which was concerned only with the ratio between the carbon dioxid given off and the oxygen consumed, and how this ratio was influenced by temperature, by light, by this kind of food or that, by mere hunger, or by starvation. This ratio, the so-called respiratory ratio or respiratory quotient, the plant physiologists really inherited from the animal physiologists, by whom it was devised with reference to the gaseous exchange that occurs in the lungs. This respiratory ratio has proved a veri-

table will-o'-the-wisp, leading investigators into a bog where their labors and their thinking were alike futile. For as a sign of what is going on within, the respiratory quotient is absolutely valueless, however interesting the facts in themselves may be. I could cite an indefinite number of investigations to indicate this. I select a few cases.

As long ago as 1885 Rubner showed* that the respiratory ratio varied in resting muscles at different temperatures.

At	8.4°	$\frac{CO_2}{O_2} = 3.28$
	28.2	1.01
	33.8	1.18
	38.8	0.91

Von Frey and Gruber† showed that in a dog's muscle, with artificial circulation, contractions are accompanied by an increase in the carbon dioxid added to the blood, but they found this increase variable (46–10 per cent.) and *less than the corresponding absorption of oxygen*, so that the respiratory ratio became lowered during contraction. Tissot‡ showed that the production of carbon dioxid in excised muscles was increased if the muscle were killed by heat or were fatigued by prolonged stimulation. The output of carbon dioxid in such cases *was not related to the rate of absorption of oxygen.* Six years ago Fletcher,§ using Blackman's apparatus, the most intricate and accurate apparatus yet devised for following gaseous exchanges, showed that the evolution of carbon dioxid from excised frog's muscles is *independent of the amount of oxygen taken up during the period.* He distinguished in the production of carbon dioxid, first, a short period (about six hours), which he thinks dependent upon the presence of oxygen; and second, a long continued evolution of carbon dioxid 'due to chemical processes occurring spontaneously within the muscle, in which complex molecules are replaced by simpler ones, with the conspicuous results of the appearance of [sarcolactic] acid and of free carbon dioxid.' He adds: 'Under suitable conditions the occurrence of active contractions in an excised muscle is *not* accompanied by an increase in the rate at which carbon dioxid is yielded by the muscle,' though oxygen is abundantly supplied then by the blood. He does find, however, an increased formation of other decomposition products.

Chauveau and Kaufmann, as long ago as 1887, found that the output of carbon dioxid from the levator muscle of a horse's upper lip was greater during activity than during rest, and *contained more oxygen than that absorbed in same time.**

A great number of researches of the same tenor can be found in botanical literature. A single example must suffice. In an elaborate paper Purjewicz shows† that the variations in the carbon dioxid produced and the oxygen absorbed during a given period under various conditions *are not parallel,* the amount of carbon dioxid ranging within far wider limits than the oxygen. Thus, the carbon dioxid varied from — 14 to 120 per cent. of the average; the oxygen varied from 0 to 48 per cent. of the average. Purjewicz, indeed, expresses his conviction that the res-

* 'Versuche über den Einfluss der Temperatur auf die Respiration des ruhendes Muskels.' *DuBois-Reym. Archiv. für Physiol.* **1885**: 38–66.

† 'Versuche über den Stoffwechsel des Muskels.' *DuBois-Reym. Arch für Physiol.* **1885**: 533–562.

‡ 'Recherches sur la respiration musculaire,' *Arch. de Phys. norm. et Path.* V. **6**: 838–844. 1894. Also 'Variation des echanges gazeux d'un muscle extrait du corps.' *Op. et ser. cit.* **7**: 641–653. 1895.

§ 'Survival respiration of muscle.' *Jour. Physiol.* **23**: 10–99. 1898.

* 'Le coefficients de l'activité nutritive et respiratoire des muscles.' *Compt. Rend. Acad. Sci. France* **104**: 1126–1132. 1887.

† 'Physiol. Unters. über Pflanzenatmung.' *Jahrb. wiss. Bot.* **35**: 573–610. 1900.

piratory ratio has no value as indicating the actual course of respiration, and would separate the taking up of oxygen and the production of carbon dioxid as two processes only indirectly related.

It is clear that such results as have been cited became difficult to reconcile with the idea that respiration is combustion, and so an attempt was made to evade the force of the facts, while maintaining the comparison, by introducing a qualifying term and speaking of respiration as 'physiological combustion.' This modification, however, blinks the difficulty; it does not remove it.

Before passing from this part of my subject I may mention another false conception, which is more or less directly dependent on the notion that respiration is combustion. One often finds respiration described as a gaseous exchange—the taking up of oxygen and giving off of carbon dioxid—a trade between the atmosphere and the body. Clearly this is another case of transferring the superficial interpretation of our own physiological processes to other organisms. The exchange that takes place between the tissues and the blood, between the blood and air in the lungs, gives the foundation, and the unessential phenomena of respiration become substituted for the essential. It would be quite as correct to describe photosynthesis as 'an exchange of gases,' for carbon dioxid is taken up and oxygen is eliminated. Yet no one ever thinks so superficially of this process.

ANAEROBIC RESPIRATION.

For three quarters of the last century it was supposed that the evolution of carbon dioxid could only occur when free oxygen was available. But in the early seventies Pflüger discovered what seemed a peculiar form of respiration. He found that a frog put into a vacuum continued to give off carbon dioxid; and presently the same phenomenon was observed by Pfeffer and others in plants. So firmly had the conception of combustion fastened itself upon physiologists, that when this anaerobic respiration came to be explained, it was supposed that certain molecules of organic matter within the cell gave up their oxygen to others, that they might thus be burned in the body furnace to yield energy. Hence arose the term intramolecular respiration.

The study of anaerobic respiration, misleading as this early interpretation of it was, has thrown in late years a very great light upon normal or aerobic respiration. Here is a process which results in the evolution of energy, and gives rise to one important end-product of aerobic respiration, viz., carbon dioxid; yet it early became evident that it could not be counted a process of combustion, at least in any sense in which combustion was then understood. Plainly the changes that were going on within the organism which enabled it to give off carbon dioxid when no free oxygen was to be had could only be a rearrangement of atomic groups within the molecule and the formation of products which were simpler than those from which they arose.

FERMENTATION.

The process of fermentation, first thoroughly explored by Pasteur, whose results have been much extended by the brilliant researches of Hansen and many others, are evidently related to those of respiration by the nature of the end products and the conditions under which the processes occur. Indeed when one compares the end products of respiration and of alcoholic fermentation he finds them to be identical in all respects. Other sorts of fermentation likewise yield many substances that are found originating in the metabolism of the higher plants.

We have, then, three modes of energy release, which are evidently closely related

if not identical; aerobic respiration, anaerobic respiration and fermentation. Their relations, so far as was known in 1898, were stated by Pfeffer in his 'Pflanzen-physiologie' and need not be reviewed.

THE COURSE OF RESPIRATION.

In translating that work Ewart wrote (p. 519): "The actual course of respiration within the protoplast is quite obscure." Pfeffer himself says (p. 551): "Our knowledge of the inherent protoplastic mechanism is too incomplete to afford a sound basis for any theory concerning the phenomena of respiration." Fortunately, knowledge in the last six years has broadened, and I believe that it is possible now to see pretty clearly what the actual course of respiration is. Perhaps you will say, to foresee rather than to see—but hypothesis must outrun demonstration. The advances to which we are indebted for deeper insight are in three fields: (1) the chemistry of proteids; (2) the course of combustion, especially at low temperatures; and (3) the nature of anaerobic respiration, and its relation to aerobic respiration. Let me speak of these in order.

CHEMISTRY OF PROTEIDS.

A knowledge of the proteids, complex as they are, could only be obtained by a study of their decomposition products. Now there is a very remarkable uniformity in these decomposition products. No matter what the organism from which they are derived, no matter how simple they are or how complex, when broken up by the process of digestion, or by boiling with acids, they yield invariably a series of products which have become in the last few years much better known. These are amino- or amido-acids; such substances as leucin, tyrosin, arginin, glutamin, glycocoll, etc. Materials of this kind are invariably present, and certain ones are so invariably present that they can be used as the basis of distinctive tests for the occurrence of digestion or similar decompositions of proteids. This gave a clue to the nature of proteids which was followed by several observers, notably by Kossel, in the study of what are believed to be the very simplest proteids, because of the fewness and uniformity of the fractions into which they break up. These are the protamines. It has become clear from the study of these simple proteids that they are made up in somewhat the same way as the polysaccharides, that is by condensation, in this case linking together a series of the amido-acids. This is possible because the amido-acids have a peculiar construction. They are, so to speak, different on different sides. On one side is an acid group and on the other a basic group; and so the amido-acids can hang together in chains, or even be condensed or polymerized to make a simple proteid. Among the amido-acids, as in the carbohydrates, there are certain atomic groups, like CH_3, CH_2, CHOH, CH_2OH, COOH, etc., which recur again and again, and in such groups the possibility of replacing a hydrogen atom or a hydroxyl radicle by some other atomic group is very great.

Note, for instance, the comparatively simple acetic acid, $CH_3 - COOH$. If we replace one of the three H atoms by the amido group, NH_2, we have at once an amido-acid, glycocoll, $CH_2(NH_2) - COOH$, which is one of the sorts of material out of which proteids can be made. Out of an alcohol or out of a sugar we may get just the groups CHOH, CH_2OH, etc., from which these amido-acids may be constructed when nitrogenous substances are present to supply the amido group NH_2. Thus the mode of construction of the proteids has been found to show a likeness to that of the complex carbohydrates, and it has long been known that the carbon groups were very much alike in both. It further ap-

pears that when the proteids are digested by any organism they break down into these fragments, of one sort and another, the amido-acids, the amides, etc., which may be put together again in new form to constitute the peculiar proteids of that particular organism. We may thus get one proteid out of any other by the breaking up of the complex molecule and the rearrangement of its constituent fragments. This fragmentation is readily accomplished by the proteolytic enzymes, which probably act on these bodies as the diastases do on carbohydrates.

OXIDATION.

The second important line of progress has been in the study of the oxidation of carbon compounds at low temperatures. For our purpose the important facts which have only recently been developed are that the oxygen of the air does not combine directly with carbon or with carbon monoxide to form CO_2 or with hydrogen to form H_2O, as has heretofore been supposed.

As long ago as 1893 Dixon's researches* on explosive gases showed that molecular oxygen was by far the most effective of the atmospheric gases in *retarding* combustion. This surprising result could not be interpreted then, and only in the light of Traube's theory and the studies of Bone and others† on the oxidation of gases like methane and ethane at low temperatures has it been possible to picture the mechanism of such combustion. This has been done by Armstrong,‡ who (with Traube) claims that the substances do not undergo direct oxidation, but hydroxylation, *i. e.*, its hydrogen atoms are successively replaced by hydroxyl radicles, with consequent splitting into various intermediate products, such as carbon monoxid and hydrogen peroxid, carbonic acid and water being the end products. Armstrong says:

> There is little reason to suppose that changes take place at high temperatures in rapid combustions in ways very different from those in which they occur at lower temperatures. * * * The effective operation is not the mere blow due to impact or the vibration caused by this in the molecule, but the conjunction of compatible molecules and the consequent formation of composite systems within which change can occur. In so far as temperature influences the formation of compatible systems, either as regards their character or the rate at which they arise, temperature has an influence, but probably not otherwise.

I ask you to notice, then, that the process of combustion is now being interpreted in the light of changes like those which have long been known in organisms under the name of hydrolysis, and are the characteristic mode of action of enzymes. Thus, when starch is acted upon by diastase it is probably by repeated reactions between water, dissociated into hydrogen and hydroxyl groups, and oxygen, in other words by continued hydroxylation that it becomes ready to fall apart into a series of dextrines and finally into maltose. Diastase in some way facilitates this dissociation. Maltase takes up the task, and maltose, further hydroxylized, cleaves into two molecules of glucose. Then zymase may lend its aid and hydrolyze the glucose molecule into lactic acid, breaking the latter still further into carbon dioxid and alcohol.

The mechanism of the digestion of starch is not known in detail, though the various intermediate products have been fairly well studied. The usual assumption made is merely that water combines with the starch under the action of diastase. I have carried the theory a little further into detail,

* 'The rate of explosion in gases.' *Phil. Trans. Roy. Soc. London* A. **184**: 97–188. 1893.

† Bone and Wheeler, 'The slow oxidation of methane.' *Trans. Chem. Soc. London* **81**: 535–545. 1902; **84**: 1074–1087. 1903. Bone and Stockings, 'Slow combustion of ethane.' *Trans. Chem. Soc. London* **85**: 693–727. 1904.

‡ 'Retardation of combustion by oxygen.' *Chem. News* **90**: 25. 1904. 'Mechanism of combustion.' *Trans. Chem. Soc. London* **83**: 1088. 1903.

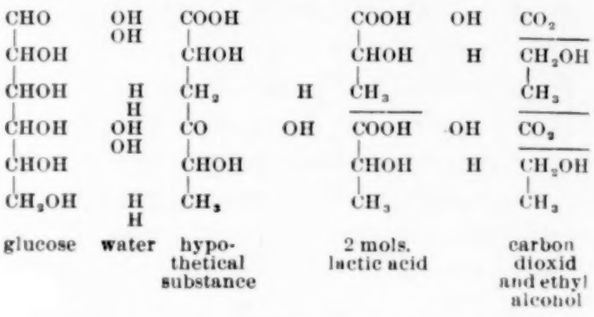
as seems warranted by the studies of combustion. It is worthy of note also that the late steps in the process, the hydrolysis of glucose by zymase, have been designated by the term fermentation. The combustion of starch has likewise not been examined, but as the end products are identical with those of digestion, it is not at all improbable that the intermediate steps are the same, though they succeed one another too fast to be followed by means at present available.

I need hardly remind you that our present ideas of the dynamics of chemical reactions forbid us to believe that such dissociation does not go on slightly at low temperatures, even when unaided. But it is so slow as to be ordinarily beyond our measurement. The enzymes seem to be mere accelerators of the several processes, perhaps preparing 'compatible systems,' as high temperature may do in combustion; perhaps entering into union with the substance they act on and forming compounds which are dissociable at ordinary temperatures in appreciable amounts.

The clue to an understanding of respiration has been found, therefore, not by comparing it to combustion, which was so long misleading, but by assimilating combustion to respiration. We may hope that chemists will restrict the term combustion or introduce a new one that will make more obvious the mode of action. Physiologists at least will do well to drop 'combustion' altogether from their vocabulary, as neither the past conception of it nor its probable use in the future conduces to clearness of thought.

NATURE OF ANAEROBIC RESPIRATION.

The third line of advance has been in a study of the relations of fermentation and anaerobic respiration. The first step was that long-sought discovery by Buchner, that the process of fermentation by yeast is brought about by the action of an enzyme which breaks up certain hexose sugars into carbon dioxid and alcohol. But a further step in advance has lately been taken. It appears from the work of Buchner and Meisenheimer* that the alcoholic fermentation is not direct, but that it occurs always in indirect fashion, as shown below.



Stěpanék has reached the same conclusion,† and Mazé‡ has found acetic acid as an intermediate product in alcoholic fermentation by a different yeast. The interest of the discovery that inactive ethylidene lactic acid is the intermediate substance in this process of fermentation lies in the fact that one of the two acids of which that is composed, namely, *d*-ethylidene lactic acid or sarcolactic acid, is formed as a product of respiration when proteids break down in the working, fatigued, or dying muscle. Fletcher observed this as a more prominent product of contracting muscles than carbon dioxid itself. Thus a regular product of fermentation is also formed in the ordinary course of respiration.

The analogy between anaerobic respiration and fermentation had been suggested early—even by Pasteur—and has thus been growing closer with each added bit of knowledge. But the precise way in which the destruction of the living substance went on in anaerobic respiration was still un-

* 'Die chemischen Vorgänge bei alcoholischen Gärung.' *Ber. Deutsch. Chem. Gesells.* **37**: 419–428. 1904.

† 'Ueber die aerobe und anaerobe Atmung der Eier.' *Centralbl. Physiol.* **18**: 188–205. 1904.

‡ 'Utilization du carbone ternaire.' *Ann. Inst. Pasteur.* **18**: 277–303. 1904.

known. Fermentation had been shown to be due to an enzyme. Was anaerobic respiration also due to an enzyme?

Of course enzymes are known to be present in a great many of the parts of plants, and the oxidizing enzymes seemed to be the sort to be sought. But none seemed to answer the conditions. At last, however, the object appears to have been attained. Stoklasa, in a series of papers published in various journals* but all dealing with the same general problem, declares he has found in various tissues of animals and in considerable number of plants an enzyme analogous to Buchner's zymase, and like it glycolytic. This enzyme he reports in leaves and roots of beet, tubers of potato, seeds, seedlings and young plants of pea, seedlings of barley, and entire plants of *Paris quadrifolia*. Confirmatory results have (naturally enough) been obtained by several students or assistants who have evidently been engaged upon portions of the problem under the guidance of Stoklasa. It is only fair to say that Mazé has strongly criticized Stoklasa's methods from the bacteriological side and declares himself unable to secure like fermentation under aseptic conditions; though Stoklasa claims to have guarded carefully against infection and to have rejected contaminated cultures. Independently, Mazé has found what he calls zymase, in connection with pea seedlings, *Aspergillus*, and *Eurotiopsis*. He declares it 'an enzyme normal to all plants, arising like all the other enzymes during vegetative (aerobic) life.' In the higher plants, however, and in most fungi it 'is oxidized with the greatest ease, so that one never finds more than a trace of it.'

Mazé and Stoklasa interpret their results somewhat differently, Mazé holding the process of fermentation to be a nutritive one,* sugar only being assimilable when fermented and the nascent alcohol thus made available, while Stoklasa believes fermentation to be merely anaerobic respiration and essentially a process for the immediate release of energy.

Confirmation comes also from another source, for Godlewski,† working with lupines, finds similar products, and concludes that their 'anaerobic respiration is identical with alcoholic fermentation, or at least in essence dependent on it.'

Moreover Kostytschew‡ and Maximow§ have found in *Aspergillus* an enzyme which is analogous to zymase and is responsible for the formation of CO_2, whether in aerobic or anaerobic respiration.

Thus several independent observers are testifying to the rather widespread occurrence of an enzyme which brings about a disruption of plant substance, under most varied external conditions, whether the

* Stoklasa, 'Identität anaerob. Atmung u. Gärung.' *Oesterr. Chem. Zeit.* 1903. (Not seen.)

Stoklasa, Jelinek and Vitek, 'Der anaer. Stoffwechsel der höh. Pfl. und seine Beziehung z. alcoh. Gärung.' *Beitr. z. Chem. Physiol. u. Path.* **3**: 460. 1903.

Stoklasa and Černý, 'Isolierung des die anaer. Atmung der Zelle der höh. org. Pfl. und Tiere bewirk. Enzymes.' *Ber. Deutsch Chem. Gesells.* **36**: 622–634. 1903.

—— 'Ueber die anaer. Atm. der Tierorgane u. ueber die Isolierung eines gärungserregenden Enzymes aus dem Tierorganismus.' *Zentralbl. Physiol.* **16**: 652–658. 1903.

Stoklasa, 'Ueber die Atmungsenzyme.' *Ber. Deutsch. Bot. Gesells.* **22**: 358–361. 1904.

Various papers in *Annales Inst. Pasteur* **18**: 1904.

* Iwanowsky in 1894 propounded the theory that alcoholic fermentation is a pathological case in the nutrition of yeast, called forth by the abnormal composition of the nutritive medium.

† 'Weiterer Beitr. z. Kennt. der intramol. Atmung.' *Bull. Acad. Sci. Cracovie* **1904**: 115–158. See also his earlier paper with Polzeniusz, *Bull. cit.*, April, 1901.

‡ 'Ueber Atmungsenzyme der Schimmelpilze.' *Ber. Deutsch. Bot. Gesells.* **22**: 207–215. 1904.

§ 'Zur Frage über die Atmung.' *Ber. Deutsch. Bot. Gesells.* **22**: 225–235. 1904.

plant be fed on one food or another,* this dissociation resulting in the formation of carbon dioxid and of various other products.

THE MECHANISM OF RESPIRATION.

Let us now focus the light coming from the chemistry of proteids, the mechanism of combustion, and the physiology of respiration, to form a picture of what goes on in the body.

First: We should conceive of the respiratory dissociation as taking place in the living material of the body and not in a food still unassimilated. Experiments with a wide range of foods have shown that they affect the intake of oxygen and the output of carbon dioxid in the most diverse ways, whence it has been assumed that the respiratory ratio varies because of the way in which the given food is oxidized. I do not say that it is not possible for the protoplasm to decompose a sugar directly or to oxidize a fat. But it must be remembered that in no case has it been experimentally proved that the food *is* directly attacked, and that all the facts can be explained on the other assumption, and some of them very much better than on the theory of direct oxidation. Moreover, the lability of proteids which have been raised to the life-level is their most striking characteristic as contrasted with their ordinary stability.

In such labile material the *second* step is easily conceivable. There occurs a shifting of the atomic groups within the molecule, perhaps as a result of the last step in their anabolism—the addition of hydroxyl groups from the water everywhere present. Dissociation follows necessarily; very slow perhaps, at ordinary temperatures and with a scanty supply of water, yet sufficient evidently for the maintenance of life. Such conditions may very well be those obtaining in resting organs, spores and seeds. But normally this cleavage may go on at a measurable rate, without anything more than the inevitable dissociation when hydroxylation has progressed to a certain point. It seems, however, that there is generally—perhaps always—a hastening of this process, and that the highly unstable protoplasm is dissociated so rapidly that it liberates not only the energy immediately utilized in growth, movement, etc., but also an excess sufficient to be easily measured by so coarse an instrument as the thermometer. Catalytic agents like the enzymes are certainly (I think I may be permitted so strong an assertion) the usual accelerators. And it is highly probable that an enzyme identical with zymase or at least analogous to it, is an active though secondary agent in this acceleration. It may very well be also that those changes outside the protoplast (whether without the organism or not) that are called stimuli accelerate still further the katabolism, even to an explosive speed in some cases.

This primary dissociation may plainly be independent of free oxygen, though it is hardly conceivable that there will not be some oxygen present unless the plant has grown under most unusual conditions, which one can scarcely realize experimentally. The products of this decomposition are not sufficiently known, nor is their precise character important for our discussion. Among them are certainly the more complex amido-acids, carbon dioxid and alcohol.

Third: Up to this point the respiratory processes are quite alike whether the plants grow in the air or apart from it. If sufficient oxygen be not present the disruptive

* See a paper by Kostytschew which has just come to hand ('Ueber die normale und die anaerobe Atmung bei Abwesenheit von Zucker' *Jahrb. Wiss. Bot.* **40**: 563–592. 1904), showing the erroneousness of Diakonow's idea that anaerobic respiration is only possible when sugar is supplied.

processes may reach an equilibrium, just as an electrolyte practically ceases to pass a current of electricity unless a depolarizer be present. So in the hydroxylation of proteids, there is needed some substance to disturb constantly, in one direction or another, the equilibrium that tends to be reached. The common agent in this is oxygen. Of course oxygen can hardly be the only depolarizer that can promote further action. Thus, Mazé found the presence of levulose conduced to the continued evolution of carbon dioxid in the absence of oxygen, and it is quite possible that levulose took up the rôle of depolarizer, though Mazé does not so interpret his observation.

In anaerobic respiration insufficient oxygen is supplied. Its products that have been most observed and are therefore (though doubtless groundlessly) counted its characteristic products, are carbon dioxid and alcohol. Indeed, lactic acid seems an equally characteristic though transient product. The fact that hydrogen has also been often recognized among them supports the interpretation of the function of oxygen just suggested, and accords thoroughly with the theory of hydroxylation. In that process hydrogen atoms from the dissociation of water would be left free in case there was insufficient oxygen to form H_2O_2.

Fourth: But if the organism can get an adequate supply of oxygen, the katabolism continues, some of the most complex previous products breaking up by hydroxylation and thermal cleavage. Among the fragments are undoubtedly some that lose in part those very groups in which sugars, alcohols, fatty acids, etc., are peculiarly rich. These are rebuilt at the expense of such foods, which therefore disappear as a result of respiration. That ethyl alcohol does not persist when oxygen is present may mean either that it is decomposed, or that in its nascent state it is assimilated in the rebuilding of proteids, for we have seen how easily acetic acid, one of its oxidation products, can be converted into an amido-acid, glycocoll, and be thus in direct line for reconstructive metabolism.

This in its fundamental features is the theory I have presented in lectures to advanced students since 1898, though always as more or less a speculation. For various details I am indebted to the recent literature already cited. Because it is capable of explaining the observed facts, which are sufficiently numerous to demand a coherent explanation, I conceive it to be entitled to the dignity of a theory. Time forbids the discussion of details, and many points have been considered that can not be here presented.

This theory maintains the direct relation of aerobic and anaerobic respiration, whose genetic connection was long since advocated by Pfeffer. Anaerobic respiration is the primary process in all organisms. Whether aerobic respiration occurs or not depends upon the availability of oxygen. The relation of fermentation to the process is not wholly clear; for although fermentation gives rise to the same products as anaerobic respiration, this may depend in part upon respiratory decomposition, such as has been described, and in part upon digestion, which, as Iwanowsky and Mazé think, render the alcohol from sugars available for assimilation. I am inclined to believe that in fermentation we deal with an exaggerated anaerobic respiration, the active ferments being plants in which zymase is produced in such amounts that it can attack sugars outside the organism and thus secure sufficient energy with a minimum destruction of the protoplasm.

ENERGESIS.

Finally, I may suggest that for didactic purposes it is desirable to have a word other than respiration to designate the disruptive

processes by which energy is released, leaving respiration to designate the more superficial phenomena of aeration with which plant physiologists are little concerned. Perhaps the word respiration is already too firmly imbedded in literature to be so limited. It will at least do no harm to propose that the terms aerobic and anaerobic *energesis* be considered, to which fermentative *energesis* may be added if necessary.

Charles R. Barnes.
The University of Chicago.

The American Chemical Society and Section C of the American Association for the Advancement of Science.

The meetings were held in the John Harrison Laboratory of Chemistry of the University of Pennsylvania, with the exception of those of the Section of Agricultural, Sanitary and Physiological Chemistry, which were held in the Dental Hall of the university. On Wednesday morning, December 28, there was a short meeting of Section C for organization. It was presided over by Professor L. P. Kinnicutt. The following officers were elected to serve during the meeting.

Councilor—James Lewis Howe.
Member of General Committee—H. P. Armsby.
Member of Sectional Committee, 1905–1909—Wm. McPherson.
Local Press Secretary—J. M. Mathews.

Following the meeting of Section C there was held the first session of the Chemical Society. President Arthur A. Noyes was in the chair.

J. A. Parker read a resolution opposing the passage of the Mann Bill, now before Congress. The resolution was referred to the Committee on Patents and Patent Legislation, and was amended to read as follows:

Resolved: That the present patent law is sufficient protection to American inventors and American industries provided that it be so amended as to require that, in order to secure protection for the legal period, the inventor must operate his process or manufacture his product in the United States on a commercial scale within two years after the issue of his patent, and must continue to do so during the life of the patent.

Professor Edward Hart then read a paper on 'Some Present Problems in Industrial Chemistry.'

He first described the Louisiana sulphur deposits which recently began to yield sulphur at the rate of 16,000 tons monthly at a cost of less than three dollars per ton. He then took up in detail the imports, exports, production and consumption of the important heavy chemicals and showed that much progress has been made in the recent past in supplying our own markets with the domestic products. This progress was most marked in metal products, of most of which we are now the largest producers. Among instances of recent progress the discovery of Mr. Gayley that dry air gave much more economical results in the iron blast furnace was cited and it was shown that at the most moderate computation this meant an addition to our national income of nine million dollars. Among the problems to be attacked by the chemist the following were cited: (1) A cheaper method for burning cement, (2) a cheap substitute for rubber, (3) an artificial cheap nitric acid, (4) extraction of potash from feldspar, (5) utilization of titanium compounds, (6) the home manufacture of coal tar products.

The speaker was of the opinion that great progress had been made in chemical industry in quality as well as quantity of product, and that we should soon lead the world in this branch of industry.

After this Professor James Lewis Howe read a paper on 'Recent Progress in Inorganic Chemistry.' This appeared in the

January number of the *Journal of the Chemical Society*, page 62.

F. W. Clarke, as a member of the International Committee on Atomic Weights, and of the corresponding committee of the society, gave an account of the changes made in the atomic weights during the year. The report of the International Committee is published in the January number of the *Journal* of the society. It was discussed by W. A. Noyes, W. D. Bancroft, A. A. Noyes and R. C. Wells.

At the afternoon meeting, the address of Wilder D. Bancroft, the retiring vice-president of Section C, on 'Future Developments of Physical Chemistry,' was listened to with great interest. It was published in SCIENCE, January 13, page 50.

On Thursday morning there was another general meeting of the society, at which the following papers were read:

The Atomic Weights of Sodium and Chlorine: THEODORE W. RICHARDS and R. C. WELLS.

Very careful analyses and syntheses of sodium and silver chlorides, made with purest materials from many sources, were made by several methods. These furnished convincing evidence of weighable traces of impurity in Stas's silver, and minor errors in his methods of work. Many observations were made which must be considered in any investigation of the highest accuracy, concerning the occlusion of impurities by precipitates, and the solubility of precipitates. Nearly a hundred quantitative experiments were made, and of these thirty ranked as final determinations. The result for the atomic weight of sodium was 23.008, and for the atomic weight of chlorine 35.473, if silver is taken as 107.930; but evidence was obtained showing that this value for silver is slightly too large. Further investigations, connected with and suggested by this work are in progress. The authors are greatly indebted to the Carnegie Institution of Washington for pecuniary assistance.

The paper will be published in the 'Publications of the Carnegie Institution of Washington' and also in the *Journal of the American Chemical Society.*

The Present Condition of Analytical Chemistry: W. F. HILLEBRAND.

The author refers to the evidence that has accumulated during the past years, showing a condition in technical analysis in this country which calls for the earnest attention of chemists, and particularly of instructors of chemistry. An opinion seems to be gaining ground that faulty instruction is at the bottom of much of the trouble. This view the author is forced to regard as not unfounded, though he thinks the faults are more commonly those of omission than of commission. He regards it as of the greatest importance that students should be made to think at every step of what they are doing and why they are doing it, that they should be made to test their distilled water and reagents as a matter of course, both as to quality and quantity of contamination, so as to have definite knowledge regarding the magnitude of the errors in their work ascribable to these impurities; that they should be obliged to check the accuracy of their work by analyzing some fairly complex material like a limestone, cement or slag, the exact composition of which has been carefully ascertained. The committee on uniformity in technical analysis of the American Chemical Society will soon be ready to send to all applicants a standard limestone of known composition, so that instructors may test their own or their students' skill as analysts, and employers that of their employees. No good work can be done unless the workman has good tools and knows how, when and why to use them. Full recognition is given of the adverse conditions confronting many, if not most, chem-

ists in technical laboratories, but the claim is made that the thoroughly grounded student will be better able to secure satisfactory results, even under adverse conditions, than the one who is taught only the quick methods of the mill or smelter, without any adequate knowledge of the pitfalls in his path and of the proper means of avoiding them. The one who is thoroughly grounded in the minutiæ of a few complex analytical procedures will be the better fitted to use and apply short-cut methods with judgment. An appeal is also made to chemists to aid the committee of purity of reagents of the American Chemical Society in securing a better quality of reagents.

Diet in Tuberculosis: Harvey W. Wiley.

The physician should select a menu adapted to each patient. The oils, especially cod-liver and olive oil, are most beneficial. Alcohol has a food value, and is, besides, a stimulant. Whiskey, brandy and other beverages have often been used to great advantage. Easily digested foods, such as milk, eggs, soups, rare meats, fruits and vegetables furnish a variety of palatable dishes. The great value of a correct diet is in helping the physician to carry the patient over a crisis by giving strength to overcome the predatory character of the disease.

Proper Diet for the Tropics: Harvey W. Wiley.

Less food is needed in the tropics than in temperate climates because less animal heat is required. Tropical fruits are perhaps the best general diet. Any large excess of protein is to be avoided.

The Ripening of Peaches: W. D. Bigelow and H. C. Gore.

A study was made of the composition of six varieties of peaches, including both early and late and of varying texture and flavor. Samples were taken at three periods, and, when possible, at four periods of their growth. First, just after the June drop; second, at the time of hardening of the stone; third, at the time of market ripeness; fourth, the time of full ripeness. The results were expressed both as percentage composition of the peaches and as grams per peach. The results obtained were compared with those obtained by the same writers in the study of the ripening of the apple. Unlike the apple, the peach has practically no starch and apparently no reserve material, at least in appreciable amount, which will increase sucrose after the peach is separated from the tree. Unlike the apple, therefore, there is no increase of sucrose after picking. There seems to be some inversion of the cane sugar with the formation of invert sugar, but such changes are not nearly so marked as in the case of the apple. Between the time of the June drop and the time of market ripeness the flesh of the peach is increased on the average about ten times, while the weight of the stone increases about seventy per cent., and the weight of the embryo ninety-five per cent. The total solids in the flesh increase about ten times in weight, the marc increases about three times in weight, although the percentage of marc in the ripe peaches was much less than in the green peaches. In the percentage composition of the peach the reducing sugar decreases throughout the life history, whereas the sucrose increases. The acid also increases from the time of the June drop until the peaches become ripe. The nitrogenous bodies, both in the form of albuminoids and in the form of amido bodies, decrease in percentage and increase in grams per peach. There appeared to be no evidence of the change of proteids into the simpler amides, or *vice versa*.

A fuller account of this work will be given in a Bulletin of the U. S. Department of Agriculture, Bureau of Chemistry.

The Liberation of Hydrogen during the Action of Sodium on Mercury: L. KAHLENBERG and H. SCHLUNDT. (Read by title.)

The results of the annual election were then announced, the following officers having been chosen for 1905.

President—F. P. Venable.
Secretary and Editor—Wm. A. Noyes.
Treasurer—Albert P. Hallock.
Councilors—W. F. Hillebrand, C. F. McKenna, H. P. Talbot, J. M. Stillman and E. H. Miller.

The reports of the treasurer, secretary, librarian and the different committees were then read.

At present the total number of members is 2,675, exclusive of 124 who have been elected but have not yet qualified. The net gain for the year is 247. The balance of current funds is $1,187.90. The committee on publications received 209 papers, of which all but 39 were accepted. The increase of about 300 pages in the *Journal* represents original work mainly.

The committee on duty-free importations stated that new and very favorable rulings had been obtained in regard to imports. The report of the committee on patent legislation has already been mentioned.

On Thursday and Friday the different sections of the society held meetings, at which the following papers were read:

PHYSICAL CHEMISTRY.

Arthur A. Noyes, chairman.

Freezing-point Depressions of Aqueous Solutions of Some Benzene Derivatives: E. H. LOOMIS.

The Behavior of the Bronzes: W. D. BANCROFT.

Copper-tin bronzes containing more than 92 per cent. copper show no inversion temperature. Bronzes containing 75–92 per cent. copper show an inversion temperature at about 500°. The tensile strength and ductility of the first group of bronzes is affected but little by heat treatment, while heat treatment has a very great effect for the second group. The strongest bronze has a composition of about 80 per cent. copper and a tensile strength of about 72,000 pounds per square inch. It is composed of β crystals with just a small amount of α crystals. The most ductile bronze has a composition of about 90 per cent. copper and gives a 40 per cent. elongation for a rod one centimeter in diameter. It consists of α crystals with just a small amount of β crystals. This work is being carried on under a grant from the Carnegie Institution.

Hydrochloric Acid Concentration Cells: W. D. BANCROFT.

Sodium amalgam concentration cells have abnormally high electromotive forces but this has been shown to be due to the heat of dilution and not to a dissociation of sodium in sodium amalgam. Hydrochloric acid and sodium chloride concentration cells with calomel electrodes have abnormally high electromotive forces; but only a relatively small portion of this discrepancy can be attributed to the heat of dilution. The balance must, therefore, be due to electrolytic dissociation.

Electrical Conductivity of Aqueous Solutions at High Temperatures: A. A. NOYES and H. C. COOPER.

Electrolysis of Chromic Chloride Solutions: H. R. CARVETH.

The writer has studied the electrodeposition of the metal from chloride and sulphate solutions and finds that the current efficiency depends upon the amount of the chromous salt present. The nature of the anode solution has a very marked influence on the efficiency; this is partly explained by the reaction between the diffusing anolyte and the chromous salt in the cathode chamber. Attention is also directed to a number of important factors which have

not hitherto been carefully controlled, although they affect the yield very materially.

The Efficiency of Centrifugal Purification: T. W. Richards.

The very great gain in time, labor and material effected by centrifugal draining and washing during the purification of crystals was demonstrated by quantitative experiments, and simple forms of apparatus were suggested which secure these advantages to the organic chemist or to the worker with small quantities of precious material.

Electro-stenolysis and Faraday's Law: T. W. Richards and B. S. Lacy.

It was demonstrated by quantitative experiments that the deposition of large quantities of silver electro-stenolytically in the middle of an electrolytic cell had no effect on the weight of the deposit of silver at the cathode, and, therefore, that Faraday's law still holds true under these peculiar conditions. This is of interest in its relation to the porous cup coulometer, although it is true that no electro-stenolytic deposits are observed on the cup under ordinary conditions.

These two papers will appear in the *Journal* of the society.

The Mercury Sulphocyanate Complexes: M. S. Sherrill and S. Skowronski.

The paper is published in full in the January, 1905, number of the *Journal* of the society.

The Solubility of Calcium Sulphate in Solutions of Ammonium Salts and of Certain other Salts: F. K. Cameron and B. E. Brown.

It is shown that the solubility curve for calcium sulphate-ammonium chloride has a maximum value corresponding to about 225 grams of the more soluble salt per liter, and about 10.9 grams per liter of calcium sulphate. From this point on, with increasing concentration of ammonium chloride, the solubility of calcium sulphate decreases, until in a saturated solution there is only 7.4 grams per liter calcium sulphate. The ammonium nitrate curve is similar to the ammonium chloride curve, the solubility being somewhat higher. Here again, with high concentrations with respect to the more soluble salts the solubility decreases until in a saturated solution of ammonium nitrate it is only about half as soluble as it is at the maximum point.

The authors give the data they obtained with a concentration of the solution with respect to calcium sulphate and other more soluble salts, such as the chlorides, nitrates and sulphates of sodium, magnesium and ammonium.

The Action of Water upon Calcium Phosphates: F. K. Cameron and A. Seidell. (Read by title.)

The Action of Solutions of Potassium Nitrate upon Tricalcium Sulphate: F. K. Cameron and J. G. Smith.

The authors studied the action of solutions of various concentrations with respect to potassium nitrate upon tri-calcium phosphate at a temperature of 20°, for various lengths of time and for various proportions of solid to solution. It was shown that increasing the concentration of potassium nitrate increased both the phosphoric acid and the calcium going into solution, but that the ratio of calcium to phosphoric acid steadily decreases until in saturated solutions of potassium nitrate the ratio is approximately that required by the formula of tri-calcium phosphate. It appears, therefore, that increasing the amount of potassium nitrate in the solution reduces the hydrolizing action of water, although the solubility of the substance steadily increases.

Molecular Attraction: J. E. Mills.

The article was a summary of work

already published (*Journal of Physical Chemistry,* June, 1904, and December, 1904) and of work along the same line yet to be published. An equation was deduced based upon the idea that the so-called cohesive forces between the molecules of a liquid could be entirely and quantitatively accounted for on the supposition of an attractive force between the molecules, the force varying inversely as the square of the distance apart of the molecules. The deduced equation was tested by an examination of twenty-five liquids over wide ranges of temperature and pressure. The measurements used were, for the most part, those made by Drs. Ramsay and Young and Dr. Young. The result undoubtedly allows the conclusion to be drawn that the intramolecular forces obey a law exactly similar to the law of gravitation, *i. e.*, the attraction between the molecules of any liquid varies inversely as the square of the distance apart of the molecules, does not vary with the temperature, and is a function of the number of molecules (mass) considered.

The results also point to the conclusion that the so-called molecular association, as in the case of water, is caused by this same molecular attraction and not by another force such as chemical affinity.

On Crompton's Equation for the Heat of Vaporization: J. E. MILLS.

An equation proposed by Mr. Crompton (*Proc. Chem. Soc.* (London), Vol. 17, 1901), $L = 2RT \log e\ d/D$ (L is heat of vaporization, R is the constant of the gas equation, $PV = RT$, T is the absolute temperature, d and D are the densities of liquid and vapor, respectively) was examined. It was shown that the latent heats so calculated were invariably and usually very considerably too high at low temperatures where the vapor pressure is small, but at high pressure, as the critical temperature of the liquid is approached, the results are in excellent agreement with the true heats of vaporization. Some important results following from this equation were pointed out. The article was published in the *Journal of Physical Chemistry,* for December, 1904.

AGRICULTURAL, SANITARY AND PHYSIOLOGICAL CHEMISTRY.

Wm. P. Mason, chairman.

Interpretation of a 'Water Examination': WM. P. MASON.

The paper will be published in SCIENCE.

The Water of Utah Lake: F. K. CAMERON.

In this paper comparisons are made of analyses of Utah Lake water covering a period of twenty years. It is shown that the mineral content of the water is continually increasing, the water containing about 300 parts of total solids in 1883 against over 1,400 parts per million of solution at the present time. This increase is mainly due to sodium chloride introduced by the seepage waters from the surrounding irrigated areas, which areas have been brought under cultivation since the first analyses were made; second, by the diversion, for irrigation purposes, of mountain streams formerly entering the lake; and third, by the relatively large evaporation from so shallow a body of water.

Determination of Oxygen consumed in Water Analysis: L. P. KINNICUTT.

The amount of oxygen consumed by a given water depends on the method used for determining this factor. Analyses of many samples of water and sewage show that the results obtained by the two English four hour methods, the 'English official' and the 'Manchester,' agree very closely with each other.

The results obtained by the four modifications of Kubel's method, which are used in this country, are not only very different from the results obtained by the English

methods, but give varying results, depending on the modification used.

We are able to make a rough comparison between the results obtained by the English methods, with those obtained by the modifications of Kubel's process, and compare with each other the results obtained by the four modifications of Kubel's process. To compare results obtained by the English methods with Palmer's modifications of Kubel's process, thirty minutes at 100° C., with potable waters multiply the former by two and one half; to compare with American Association for the Advancement of Science method ten minutes at 100° C., potable waters multiply by two, with sewage multiply by four; to compare with Public Health Association method, five minutes at 100° C., with potable waters no change, with sewage multiply by two and a quarter; to compare with Massachusetts State Board of Health method, two minutes at 100° C., with potable waters no change, with sewage multiply by two.

To compare in the same way with each other the results obtained by the modifications of Kubel's process the following table can be used, taking the results obtained by the M. S. B. H. method as unity.

	M.S.B.H.	A.P.H.	A.A.A.S.	Palmer's
Potable waters..	1	1.25	1.75	2
Sewage	1	1.50	2	2.50

Standard Methods to be used in the Sanitary Analysis of Water: L. P. Kinnicutt.

A paper showing that the results obtained in the sanitary analysis of water depend to a large extent on the method of procedure by which the various determinations are made, and that at the present time there is no conformity among chemists as to the method of procedure. A variation of one hundred per cent. in certain determinations, depending on the process used, is not uncommon. The only way of obtaining results which shall be comparable is to follow the lead of the official agricultural chemists of this country and adopt standard methods to be used in the analyses of potable waters and sewage.

Determination of Nitrites in Water: R. S. Weston.

Biochemistry of Sewage Purification, the Bacteriolysis of Peptones and Nitrates: S. D. Gage.

In the treatment of sewage by modern biological methods, a great variety of chemical reactions occur, all of which are caused directly or indirectly by the action of bacteria. It was shown that bacteria common in sewage disposal are able to produce ammonia from organic matter, to reduce nitrates to nitrites, to ammonia and probably to elementary nitrogen, to liberate nitrogen from solutions of organic matter and also to fix atmospheric nitrogen. Many sewage bacteria also probably produce the lower oxides of nitrogen as reduction products of nitrates, which oxides may play an important part in the further decomposition of the organic matter in solution either through catalytic action or by direct chemical reaction. The amount of ammonia and the amount of nitrates reduced vary widely with different classes of bacteria, as does also the character of the reduction products of the nitrates. It has been found that a majority of the bacteria common in sewage and in sewage disposal systems reduce nitrates and form ammonia from organic matter, although these two functions are not always synonymous with the same species. Furthermore, it was found that there was a close relation between the ability of bacteria to peptonize insoluble organic matter and the ability to reduce nitrates and to ammonify this organic matter, although many exceptions have been noted to this rule.

The paper will be published in the *Journal* of the society.

An Apparatus for the Rapid Estimation of Urea in Urine: F. C. ROBINSON.

A Comparison of Organic Matter in Different Soil Types: F. K. CAMERON.

A comparison is made of soils with different organic content and soils of various textures, colors, etc., and the conclusion is developed that the organic matter contained in soils is not a general type characteristic. Within any soil type, however, the content of organic matter can be correlated to color and other properties of the soil, and is an important characteristic.

Availability of Nitrogen in the Soil: G. S. FRAPS. (Read by title.)

Homicide by Aconite Poisoning and the Quantitative Estimation of Aconite in the Human Body: H. C. CAREL.

INDUSTRIAL CHEMISTRY.

Edward Hart, chairman.

Wood Turpentine: W. C. CARNELL.

Spirits of turpentine has, for many years, been made by the distillation of the refuse wood of the southern long-leaf pine tree. As much of it was made in a crude way and put on the market poorly refined, it is now almost generally regarded as something different from spirits of turpentine and has received such names as wood spirits, spiritine, turpentine substitute, stump turpentine, etc.

When this refuse wood is distilled by steam and the temperature kept sufficiently low, a product is obtained which can be refined by one redistillation and having all the physical and chemical properties of spirits of turpentine made in the regular way. Its color is water white. Odor, when first made, is somewhat characteristic; when several months old same as regular spirits of turpentine. Specific gravity, 0.862 to 0.876 at 15° C. Distillation, 90 per cent. comes over between 160° and 180° C. Evaporation at 100° C. Residue, 1.13 per cent.

If properly made the product obtained from the refuse is identical with the distillate from the turpentine dip.

The Detection of Rosin in Varnishes: A. H. GILL. (Read by title.)

Best Method for the Analysis of Refined Copper: G. L. HEATH.

The Education of Technical Chemists: I. A. PALMER.

The average good man who enters a commercial laboratory from one of our technical schools is deficient in an understanding of the elementary principles of chemistry and in a knowledge of the ordinary methods of analysis. Most of the manuals are of little assistance, and the rule of thumb man fails when required to devise new methods to meet certain conditions. The technical chemist should be a man of broad education, and as such stands a far better chance of promotion than one of poor training. Technical schools should require more rigid qualifications for entrance, and should not permit lax scholarship. The attempt to imitate commercial practice is of doubtful utility, for there is no time for it, and the ideas carried away by the students are often wrong ones. The technical school should give a broad education in the principles of applied science, with just sufficient laboratory and shop practice to illustrate these principles. The training of the head as well as the hand should be the object sought.

The Utilization of Fine Ores, Flue Dust, Stove Dust, Down-comer Dust, etc., in the Blast Furnace: J. C. ATTIX.

At large furnace plants vast quantities of these materials accumulate, especially where the furnace burden is made up largely of Mesaba or other fine ores or concentrates. Many plans have been devised for working these fine materials and quite a number patented.

Some of the materials used have been

tar, glue, molasses, lime, asphalt and cement, all of which have practically been abandoned.

The method here used is to mix the fine materials with soft coal in varying proportions of from 12½ per cent. to 50 per cent. by weight, and then coke the coal. The coal in coking thoroughly incorporates the fine materials, and when charged into the furnace carries them down beyond where they can be carried over mechanically by the blast, and down to the zone of reduction or fusion, making a self-fueling and in many instances a self-fluxing ore. The plan is applicable at any plant running three or more stacks, or wherever the by-product ovens are used, or wherever the coke is made at or near the furnace.

INORGANIC CHEMISTRY.

James L. Howe, chairman.

The Effect of Water on Rock Powders: A. S. Cushman.

The results of investigations on the effect of water on rock powders, which have been carried on in the Division of Tests of the U. S. Department of Agriculture, were given. It has been found that wet grinding increases the binding power or tendency of the particles to cement together. This effect seems to be accompanied with direct decomposition of certain constituents of the rock magma, which results in forming colloidal films on the particles. The word 'pectoid' is suggested to describe this condition. Most rock powders that have been ground wet show an alkaline reaction to indicators, but if the water is filtered out the reaction is not usually shown. This observation is in line with the well-established fact that coagulated inorganic colloids have the power of occluding the bases from solutions of neutral salts. The analogy between the reactions that take place when Portland cement, powdered glass and rock powders are acted on by water was pointed out.

On the Complexity of Thorium: Fritz Zerban.

The work done by Chas. Baskerville on the elementary nature of thorium was repeated under similar conditions and his results were confirmed.

In addition, the acetylacetonates of the three new constituents were prepared according to Biltz's method. The three substances obtained show all the same melting point, viz., 171° C.; by mixing them together, the melting point is not lowered. (Biltz made similar observations in the cases of neodymium and praseodymium.) But the acetylacetonates of berzelium, carolinium and new thorium differ in their chemical behavior towards alcohol. Determinations of the atomic weight which were carried out with the acetylacetonates by Biltz's method, assuming the formula $Me(C_5H_7O_2)_4$, resulted in 225 for berzelium and 239 for carolinium.

The metanitrobenzoates of carolinium, berzelium and new thorium, prepared by Neish's method, could not be obtained in crystalline form.

Thorium from Brazilian monazite sand was fractioned into three constituents in the same way previously applied to thorium from North Carolina monazite sand; the percentage of berzelium and carolinium, however, appeared to be smaller.

On the Detection of Hydronitric Acid and Hydrazine in their Inorganic Compounds: A. W. Browne.

A blood-red coloration is produced when ferric chloride is added in excess to a neutral or very slightly acid aqueous solution containing free hydronitric acid or its salts, or holding in suspension the comparatively insoluble lead, silver and mercurous compounds.* The color is destroyed by

* See Dennis and Browne, *Jour. Am. Chem. Soc.*, **26**, 577 (1904).

acids, and to some extent by salts of organic acids. With the exception of sulphates, salts of the mineral acids in general have no effect. One part of N_3 in 100,000 parts of solution may be detected. Trinitrides must be separated from sulphocyanates and acetates, should these be present, before the addition of the ferric chloride takes place.

Hydrazine may be detected by making use of either of the following facts concerning its inorganic salts: (1) When heated with nitric acid they are oxidized, yielding hydronitric acid; (2) when treated with silver nitrite under proper conditions they yield silver trinitride.

Tungsten Hexabromide: F. F. EXNER. (Read by title.)

Reaction between Zinc and Copper Sulphate: A. J. HOPKINS. (Read by title.)

Non-Existence of Copper Hydroxide: A. J. HOPKINS. (Read by title.)

Notes on the Absorption of Hydrochloric Acid as a Basis for Standard Solutions: A. T. LINCOLN.

The author described a simple method, in which the amount of hydrochloric acid absorbed in a given quantity of water is determined by weighing, and gave results obtained by his students in using the method.

A New Burette Holder: A. T. LINCOLN.

A New Method of Determining the Oxygen in the Air: I. W. FAY.

The apparatus consists of a stout glass tube, twenty-one inches long and an inch in diameter, sealed at one end and ground evenly at the other. Rods of phosphorus eleven inches long and one eighth inch in diameter are held in place at the closed end by a perforated rubber diaphragm one half inch thick. A paper scale, eight inches long and divided into 200 divisions, is glued to the tube so that the 200 mark is at the open end. The tube is kept full of water when not in use. For a determination, pour out the water down to the zero mark, close with a glass plate and invert in a small vessel of water. When the oxygen has been removed, replace the plate, turn the tube upright and read the volume of gas. Correct for the reduced tension of the gas when the tube is inverted. Then two divisions on the scale are equivalent to one per cent. of oxygen.

A Modified Westphal Balance for Use with Solids: F. N. WILLIAMS.

Reactions in Liquid Ammonia: E. C. FRANKLIN.

Liquid ammonia resembles water in many of its properties, such as high specific heat, heat of volatilization, critical temperature and pressure, and high dielectric constant. Both are associated liquids, both combine with many salts, and both are good ionizing solvents. The reactions of acid and basic amides dissolved in liquid ammonia are closely analogous to the reactions between bases and acids in water, as shown by the general equations:

$$MNH_2 + AcNH_2 = AcNHM + NH_3,$$

and

$$2MNH_2 + AcNH_2 = AcNM_2 + 2NH_3.$$

Reactions of the types below were also studied:

$$AgNO_3 + KNH_2 = AgNH_2 + KNO_3,$$

$$Pb(NO_3)_2 + 2KNH_2 = PbNH + 2KNO_3 + NH_3,$$

and

$$BiI_3 + 3KNH_2 = BiN + 3KI + 2NH_3.$$

It was further shown that salts of mercury, arsenic, etc., when dissolved in ammonia undergo 'ammonolysis' in much the same way that they are hydrolyzed in water. A number of other points of resemblance were given. The article will appear in the *Journal* of the society.

ORGANIC CHEMISTRY.

James F. Norris, chairman.

Laboratory Instruction in Organic Chemistry: JAMES F. NORRIS.

An account of the methods used by the author. Great stress is laid on the work in the laboratory, instead of spending too much time on lectures. An important part of the work is the identification of unknown pure substances and mixtures by a systematic study of class reactions and the determination of physical constants.

The Detection of Palm Oil when used as a Coloring for Fats and Oils: C. A. CRAMPTON and F. D. SIMONS.

Methods are given for the identification of the presence of palm oil in cotton-seed oil which is to be used in the manufacture of oleomargarine. Also two colorimetric tests are given for its detection in oleomargarine itself.

The Detection of Renovated Butter: C. A. CRAMPTON and F. D. SIMONS.

In this paper the difficulties attending the identification of this product were discussed. Notes were given concerning several recent and promising methods for its detection.

A Method for the Rapid Analysis of Sugar Beets: DAVID L. DAVOLL, JR. (Read by title.)

The Rapid Detection of 'Beading Oil' in Whiskeys: O. S. MARCKWORTH. (Read by title.)

A Rapid Gasometric Method for the Determination of Formaldehyde: G. B. FRANKFORTER and RODNEY WEST. (Read by title.)

The Action of Permanganate and Sodium Peroxide upon Formaldehyde, with a Determination of the Heat of Combustion: G. B. FRANKFORTER and RODNEY WEST. (Read by title.)

Firpene, a Terpene and its Comparison with Pinene: G. B. FRANKFORTER and FRANCIS FRARY. (Read by title.)

The Crystalline Alkaloid of Calycanthus Glaucus: H. M. GORDIN. (Read by title.)

The Hydrocyanic Acid Content and Some Other Properties of Cassava: C. C. MOORE.

Methylamine as a Solvent: H. D. GIBBS. (Read by title.)

The Oil of Thymus Vulgaris: W. O. RICHTMANN.

Investigated the influence of soil on oil of thyme (*Thymus vulgaris*). Plants grown on light sandy soil, well drained and somewhat elevated, yielded 0.20 per cent. of red oil containing 45 per cent. of thymol. Other plants grown on heavy clay soil, poorly drained, near the river level yielded 0.22 per cent. of oil. It contained 42 per cent. of thymol.

On Thursday evening Professor Arthur A. Noyes, the retiring vice-president of Section C, gave a most interesting address on the 'Preparation and Properties of Colloidal Solutions,' illustrated with many experiments. It was a valuable summary of the work that has been done in that field, and will be published in the February number of the *Journal* of the society.

On Friday morning there was a general session of Section C, presided over by L. P. Kinnicutt. The report of the committee on indexing chemical literature was presented by Dr. James Lewis Howe, and was referred to the council with the request that it be printed. The following papers were presented:

The Nature of Amorphous Sulphur: ALEXANDER SMITH.

It was shown by consideration of the change in mobility, the solubility, the dilatation and the absorption of heat, that there are two liquid states of sulphur. That forming the greater part of the liquid phase up to 160.1° is pale yellow, and mobile, its coefficient of expansion dimin-

ishes and its solubility in triphenylmethane increases as the temperature rises. This state is named S_λ. The form which constitutes the greater part of the liquid from 160.1° onward is deep-brown in color and very viscous. Its coefficient of expansion increases and its solubility in triphenylmethane diminishes as the temperature rises. This state is named S_μ. Amorphous sulphur is supercooled S_μ.

On the Constitution of Portland Cement and the Cause of its Hydraulic Properties: CLIFFORD RICHARDSON.

The paper was read before the Association of Portland Cement Manufacturers, June, 1904, and has been published in pamphlet form.

Bivalent Carbon: JAMES F. NORRIS.

An attempt to prepare compounds of the type $C\begin{matrix}R\\R'\end{matrix}$, analogous to CO, in which the radicals, R, will have the same energy as oxygen in carbon monoxide. In this way it is hoped to avoid polymerization into $R_2C=CR_2$.

The Need of Action Regarding the Adulteration of Foods and Drugs: LEON L. WATTERS.

A brief review of the subject, in which the need of legislation was illustrated by examples that had come under the notice of the author.

The members of Section C and of the society were invited to visit numerous manufacturing establishments. A list of these was published in SCIENCE, for January 6, page 5.

The visiting chemists unanimously tendered a vote of thanks to the University of Pennsylvania, and especially to Professor Edgar F. Smith, his associates, and to the proprietors of the establishments mentioned.

Dr. C. F. Mabery was nominated by the sectional committee to be vice-president of Section C for the New Orleans meeting and was elected by the general committee.

C. E. WATERS,
Press Secretary.

Transmitted by
CHARLES L. PARSONS,
Secretary of Section C.

SECTION F, ZOOLOGY, OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION F met for organization on December 28, but no papers were read until after the adjournment of the sessions of the American Society of Zoologists. The officers for the St. Louis meeting were as follows:

Vice-President—C. Hart Merriam, U. S. Department of Agriculture.

Secretary—C. Judson Herrick, Denison University.

Councilor—C. B. Davenport, Carnegie Institution.

Member of General Committee—C. H. Eigenmann, Indiana University.

Sectional Committee—C. Hart Merriam, E. L. Mark, C. Judson Herrick, H. F. Osborn, S. H. Gage, C. H. Eigenmann, H. B. Ward, Frank Smith.

For the New Orleans meeting H. B. Ward was elected vice-president and W. E. Ritter member of the sectional committee.

The sectional address by E. L. Mark, entitled, 'The Bermuda Islands and the Bermuda Biological Station for Research,' was not read on account of the absence of the author. Nineteen communications were presented.

Natural and Artificial Parthenogenesis: ALEX. PETRUNKÉVITCH, Harvard University.

Heredity of Coat Characters in Guinea-Pigs and Rabbits: W. E. CASTLE, Harvard University.

1. Albino coat and angora coat are recessive Mendelian characters in heredity in guinea-pigs and rabbits.

2. Rough, or 'Abyssinian,' coat is in guinea-pigs dominant over normal or smooth coat.

3. The three coat characters mentioned are independent of each other. Each may exist either apart from or associated with one or both of the others.

4. Accordingly, cross-breeding involving the three pairs of alternate characters results in the production ultimately of eight visibly different classes of individuals, but of twenty-seven really different classes.

5. The principle of gametic purity is realized in a general way but not absolutely, for cross-breeding induces variability in the intensities of characters.

6. The gametes formed by certain recessive individuals are prepotent. This prepotency is hereditary.

Tropical American Fresh-Water Fishes: C. H. Eigenmann, Indiana University.

The Early Development of Chordates in the Light of the Embryology of Ascidians: E. G. Conklin, University of Pennsylvania.

Owing to the high degree of differentiation of the egg and early cleavage stages of ascidians, the small number of cells present during gastrulation and organogeny and the known cell-lineage of the principal organs of the larva, the ascidian egg is the most favorable in the whole phylum of the Chordata for an exact study of the early development. Under these circumstances it is worth while to compare the development of ascidians with that of other chordates, whatever may be thought of their phylogenetic position in the phylum.

In ascidians the animal (maturation) pole of the egg finally comes to occupy a position between the anterior and ventral poles of the larva and the chief axis of the egg is antero-ventral and postero-dorsal in direction. In other chordates the axial relations of the egg and larva are not certainly known, but there is considerable evidence that *Amphioxus* and the frog are like the ascidians in this respect.

In ascidians, the frog and possibly in *Amphioxus* also the spermatozoon either enters the egg at the posterior pole or moves to this pole after its entrance; in the two former classes the copulation path of the sperm within the egg lies in the future median plane, though in the case of the ascidians this plane is not determined by the path of the sperm, but is already established before fertilization.

In ascidians the cleavage of the egg is bilaterally symmetrical; the same is the case with several other classes of chordates; the resemblances between ascidians and *Amphioxus* being especially close. Probably in all chordates with holoblastic cleavage the third cleavage plane cuts off four ectodermal cells at the animal pole; in ascidians the four cells at the vegetal pole are endodermal, mesodermal and neural plate cells.

In ascidians and amphibians the blastula and gastrula are bilaterally symmetrical and the closure of the blastopore takes place chiefly by the overgrowth of the dorsal lip; probably the same is also true of *Amphioxus*.

Among ascidians the chorda and neural plate arise from a crescent of chorda-neuroplasm which surrounds the anterior side of the egg and gives rise to the dorsal lip of the blastopore. In many respects this crescent resembles the 'gray crescent' of the frog's egg and it seems not unlikely that here and in *Amphioxus* also the chorda and neural plate arise as in ascidians. In all of these classes the neural plate comes from the outer layer of cells of the dorsal lip, while the chorda comes from its inner layer. In ascidians and the frog the anterior limit of the neural plate reaches about one third of the way from the equator to the animal pole; the same is probably true of *Amphioxus* also.

The mesoderm of ascidians comes from a crescent of mesoplasm which surrounds the posterior side of the egg just dorsal to the equator. The substance of the crescent is later infolded in the posterior and lateral lips of the blastopore and its anterior portion lies alongside of the notochord. There are no mesoblastic teloblasts here, but with this exception this condition closely resembles Hatschek's account of the origin of the mesoderm in *Amphioxus*. The method of origin of the mesoderm in the ascidians supports Rabl's theory that the peristomal mesoderm is primary, the gastral secondary, and that the latter is derived from the former.

The Skin, Lateral-Line Organs and Ear as Organs of Equilibration: G. H. PARKER, Harvard University.

Equilibration, as exemplified by the upright position of man, is in part carried out through the eye, the ear, the sense of touch and probably other senses such as the muscle sense. It is a reflex involving sense organs and muscular response; hence the term '*sense* of equilibrium' is inappropriate. The lateral-line organs of fishes have been supposed to be organs of equilibration. Lee has shown that when the central end of the cut lateral-line nerve in the dogfish is stimulated, compensating movements occur in the fins; but these movements can also be called forth by stimulating the skin in regions where no lateral-line organs occur. Hence the skin is as much an organ of equilibration as the lateral-line organs. Both skin and lateral-line organs are, however, inferior to the eye and the ear as organs of equilibration. The lateral-line organs are stimulated by water vibrations of low rate, *i. e.*, six per second.

The ear of the squeteague consists of a utriculus with three semicircular canals and a sacculus containing a large otolith. The cavities of the utriculus and of the sacculus do not communicate with each other. When the utriculus and its semicircular canals are destroyed, the fish shows equilibration disturbances, but no loss of hearing. When the otoliths of the sacculi are made motionless by pinning them against the lateral (non-nervous) walls of the cavities in which they are, equilibrium remains normal but hearing is for the most part lost. In the fish ear the utriculus is the organ of equilibration, the sacculus that of hearing.

The skin, lateral-line organs and ears represent, figuratively speaking, three generations of sense organs. The oldest is the skin stimulated by varying pressures, such as are produced by irregular currents, and capable of initiating equilibration responses. From the skin have been derived the lateral-line organs stimulated by water vibrations of low rate, and also significant for equilibration. Finally, from the lateral-line organs have come the ears stimulated by water vibrations of a high rate and important for equilibration. The ear, unlike the skin and lateral-line organs, is differentiated for its two functions, the sacculus for hearing, the utriculus for equilibration.

Comparison of the Habits and Mode of Life of Amphioxus and Ammocœtes: S. H. GAGE, Cornell University.

1. Both *Amphioxus* and *Ammocœtes* live in the sand completely covered. If the head is projected or the entire animal remains out in the water on top of the sand, it is a sign of insufficient oxygen, too great heat, or illness on the part of the animal.

2. By repeated and continuous observation day and night I am led to believe that when in good condition the two forms remain constantly under the sand day and night; they change their position in the sand from time to time, however.

3. In entering the sand from the water there is a swimming motion until a consid-

erable part of the body is covered, then there is a snake-like movement in the sand and the animal quickly draws itself completely under. With the *Ammocœtes* the process of entering the sand is performed slowly enough to enable one to see all the steps. With *Amphioxus* and *Asymmetron* the movement is so rapid in vigorous individuals that one can not see the details. They seem to enter the sand like an arrow. When the animal becomes weakened from any cause or weary by much swimming and entering the sand, the movements become sufficiently slow to enable one to follow the steps.

4. *Ammocœtes* always enters the sand head first. *Amphioxus* usually goes head first, but may enter the sand tail first.

5. Both forms feed continuously, the food being derived from the respiratory stream entering the common branchio-esophageal chamber. In *Amphioxus* the respiratory stream is produced by ciliary action. In *Ammocœtes* the stream is produced mostly by muscular action on the two folds of the velum.

6. From the manner of feeding in nature it is easy to carry on feeding experiments. Any food, if finely enough divided to pass the sieve guarding the hood or oral entrance, will find its way into the digestive tube.

7. While both these forms live normally under the sand, each has a free life—the *Amphioxus* in its beginning or larval stage, and *Ammocœtes* in its adult or terminal stage.

8. *Method of Capture.*—With *Amphioxus* in Bermuda the animals live most abundantly in places where there is a current. The depth of the water is not, apparently, of great importance, as they were obtained in depths of a few inches up to a depth of thirty to sixty feet. It is only necessary to scrape up some of the sand with a dredge or dipper and look over the sand. When exposed to the air the animals wriggle vigorously and then are easily seen. If they remain quiet, they are seen with difficulty, they look so much like the sand. *Ammocœtes* is taken in the same way. It usually lives on the edge of a stream and it is easy to shovel up the sand and mud and look it over. The wriggling movement helps here also, as the coloration of the animal and that of the sand are almost identical.

9. *Hardiness of the Two Forms.*—Both are very hardy, and hence it is easy to keep them in the laboratory. Food will be supplied by the water, or one may feed them any desired food, as cooked flour, finely divided yolk of hard boiled egg, etc.

10. It was found possible to keep *Ammocœtes* in the laboratory from four to six months without doing more than change the water occasionally. *Amphioxus* and *Asymmetron* were captured the middle of August in Bermuda, taken to Ithaca in fruit jars of sand and sea water, and in this way some of them lived until the first of December. This experiment shows, I think, that it is entirely practicable to have living *Amphioxus* for study and experiment in our northern and inland laboratories.

Vitality of Mosquito Eggs: John B. Smith, Rutgers College.

The salt marsh mosquito, *Culex sollicitans*, lays its eggs in the soft mud on salt meadows and these eggs may remain for months, losing nothing of their vitality. After lying dry for a long time a large percentage hatches within a few hours after becoming covered with water. The remainder lie dormant for a period long enough to enable the first lot to reach full growth and then, if they are yet water covered, most of them hatch. A few eggs of each brood lie over until the year following, and all the eggs of the last brood hibernate. The first spring brood of these

mosquitoes is the largest of the season because it contains the accumulation of all the eggs remaining unhatched for any reason from the summer previous. Migrating adults of this first brood live until September and the additions from later broods give the impression of large summer broods, whereas, in fact, the late broods are less numerous than the earlier.

Light Organs of the Firefly, Photinus marginellus: ANNE B. TOWNSEND, Friends Select School, Philadelphia.

Investigations of physicists have shown the light of the firefly to be the most perfect known; not more than one one-thousandth of the energy expended is converted into heat. The nature of the process of photogeny has not been conclusively determined, although the theory which has most credence is that the light is caused by the oxidation, in alkaline media, of some substance produced by the photogenic cells. Radziszewski has found carbon compounds, similar to those found in living organisms, which are luminous under such conditions.

The purpose of the author's study has been to find what light the structure of the organs throws upon these theories. The light organs of the male *Photinus marginellus* are two plates lying directly upon the hypodermis of the fifth and sixth abdominal segments. These organs are made up of two clearly defined layers: the dorsal, in which the cells are filled with a dense content of opaque granules, and a transparent ventral, the truly photogenic layer. Within the ventral layer the tracheæ branch profusely in an arborescent manner. The vertical tracheal trunks with their branches are surrounded by cylinders of transparent tissue. Between the cylinders are parenchyma cells, irregular in size and outline, and containing fine granules. At the periphery of the cylinders the tracheæ send out fine tracheoles, without chitinous intima, which anastomose, thus forming a close network of thin-walled air capillaries. When fresh tissue is studied under a microscope in the dark room the light is found to be uniformly distributed through the area of this tracheolar network, the cylinders appearing as non-luminous spots. Crushed light organs placed in oxygen respond instantly with increase of brilliancy. The light extinguished by CO_2 reappears instantly when the tissue is placed in oxygen. Experiments with a ctenophore, *Mnemiopsis leidyi,* show similar results with oxygen. Tissue in alkaline solutions becomes brilliantly photogenic under the influence of oxygen. The light is wholly extinguished when tissue is placed in acid solutions and does not reappear when oxygen is introduced. When the acid solution is made alkaline, the tissue again becomes photogenic.

Color Nomenclature: R. M. STRONG, The University of Chicago.

The color terms used in biology are neither logical nor precise. An attempt to reduce color terminology to something like a precise system was made by Ridgway in 'A Nomenclature of Colors for Naturalists * * *' (1886). This publication was useful, particularly among ornithologists, in securing more uniformity in the naming of colors, but it employed the color terms in common usage among artists, dye-makers, etc. There is no general agreement concerning the spectral positions of these colors, and samples taken from various sources show very great variations.

The color system advocated by Milton Bradley in his 'Elementary Color' (1895) is both logical and precise. It is founded upon six standards with definite spectral positions. These are red, orange, yellow, green, blue and violet. All other 'pure' colors are obtained by combining these; thus we get 'blue-green,' 'violet-red,' etc. Dull or 'broken' colors and shades and

tints of the so-called 'pure' colors are produced by adding varying amounts of black and white. Mr. Ridgway has himself adopted this system and is elaborating it for practical work in biology.

Popular Knowledge of Common Birds: EDWARD L. RICE, Ohio Wesleyan University.

Statistics showing the number of common birds known by students electing work in bird study in Ohio Wesleyan University during the years 1902–1904. Data have been collected for 71 women and 55 men, both before and after the course. For ease in comparison a limited list of 75 species of birds has been used, the list containing all the very common birds except the English sparrow. The number of birds known at the beginning of the course was startlingly small, the average for the whole class being 21. The average record of the men (27) was decidedly above that of the women (17). About 12 per cent. of the students (14 women and 1 man) knew 10 birds or less. The lowest number reported was 4. No bird was known by all students, the robin (known by all but one) heading the list. Bob-white, crow, hummingbird, blue jay, red-headed woodpecker, bluebird, mourning dove and cardinal followed in order named. The record at the close of the course showed the following averages: for women, 45; for men, 56; for all students, 50.

Notes and Queries as to: (a) The Cerebral Commissures of the Elephant Shrew, Macroscelides; (b) The Brain and Heart of a Manatee, and what is believed to be the Smallest Known Sirenian Fetus; (c) The Brains of various 'Fishes,' including the Rare Japanese Shark, Mitsukurina; (d) The Swallowing of a Young Alligator by a Frog: BURT G. WILDER, Cornell University.

In the African *Macroscelides* G. Elliot Smith has described and figured the callosum as long, but the splenium as terminating in a point without the usual continuity with the mesal or commissural part of the fornix; his specimen was not perfectly preserved and the only example examined by the speaker has not enabled him to determine the facts; the apparent condition is unprecedented and difficult to explain; well hardened brains should be carefully sectioned. Just the reverse condition is presented by the brain of a manatee that was hardened within the cranium in 1885 by the continuous injection of alcohol; not only do the callosum and the fornicommissure constitute a single continuous area, but there is no sign whatever of the pseudocele ('fifth ventricle' or ventriculus septi pellucidi); other unusual features are the great size, especially the height, of the paraceles ('lateral ventricles'), the caudal extension that may, perhaps, represent the postcornu, and the decided ental elevation that converts the deep lateral (Sylvian?) fissure into a 'total' fissure. The heart may not differ materially from those previously examined, but its preparation by continuous alinjection displays to advantage the independence of the ventricular apexes which is characteristic of the sirenians. The fetus has the tail at less than a right angle with the trunk and the head is strongly flexed; between the two curvatures it measures about 55 mm., a little over 2 inches; it was figured and described in the *American Journal of Science,* in August, 1875, but has been commented upon only by Murie; the minute papilla on the ventral side of the tail has not yet been interpreted. The brain of *Mitsukurina* is probably now seen for the first time; most of the features are like those of other low sharks, but the olfactory crura are very long; the spiracles are far ventrad of the eyes, and not as figured in Jordan's example. The speaker has already published papers respecting the 'fish' brains exhibited, the *Polyodon* in

1875, the *Chimaera* in 1877, and the *Ceratodus* in 1887. Contrary to supposed conditions at the first date, the speaker now believes that in teleosts the olfactory bulbs are always solid, and that their hollowness in ganoids is a diagnostic character. Some progress has been made upon the peculiar conditions presented in the chimæroids, but much remains to be done with specimens specially prepared. Attention was again called to the ventral extension of the cerebral hemispheres in the dipnoans, and to their remote affinities with the ganoids. If the account by T. J. Parker of *Scymnus* (or *Scymnorhinus*) in 1882 is correct, that shark presents a nearer approximation to the ideal type of the vertebrate brain than any other form, but more specimens should be studied. There was submitted a dichotomous arrangement of the vertebrates above the lampreys, differing in some respects from that published in the *Proceedings* for 1887, and in the *American Naturalist,* Vol. 21, 913 and 1033. It is based mainly upon encephalic and cardiac characters. For the first time stress was laid upon the absence from all the holocephala of the rectal pouch which is a constant and peculiar feature of all sharks and rays.

The Feeding and Other Reactions of Actinian and Coral Polyps: J. E. DUERDEN, University of Michigan.

The paper describes the reactions of actinian and coral polyps to mechanical and chemical stimuli, founded upon experiments conducted in the Hawaiian Islands during a recent visit of the writer under the auspices of the Carnegie Institution. Studies similar to those of Loeb, Parker, Torrey and Nagel were carried out upon two species of actinians (*Cribrina*), preliminary to those upon the corals *Fungia* and *Favia*. The principal results are a demonstration of the important part played by mucus in the feeding and other processes of the two groups of polyps, the conditions governing the inhalent and exhalent currents of the stomodæum, and the movements of small and large particles over the disc. They may be summarized as follows:

1. Small, non-nutritive particles falling on the disc and tentacles become embedded in a superficial layer of mucus always present. They may remain there for some time, dependent upon the state of activity of the polyp. In the end the mucus is broken up into shreds or patches and, with the embedded particles, is wafted away by exhalent currents from the stomodæum.

2. Nutritive substances lead to an opening of the mouth, the establishment of an inhalent stomodæal current, and a more rapid secretion of mucus, surrounded by which the substances are indrawn into the digestive cavity. An inhalent current being established, objects are indrawn independently of their nutritive value.

3. In actinians the transference of food to the mouth is largely assisted by the movements of the tentacles, disc, and upper part of the column; but in corals the stomodæal currents, assisted by the secretion of mucus, are the principal agents. A complex system of mucous streams is beautifully shown in compound corals.

4. The movement of heavier particles over the disc is largely due to thigmotactic or recovery reactions on the part of the polyp. Attention is drawn to the importance of this in the conditions under which many actinians and corals live.

5. The correlation of the various reactions with the anatomical structure of polyps is considered, and comparison is instituted between the reactions of polyps as fixed radiate organisms with those of free bilaterally symmetrical animals.

Cœlosporidium blattellæ, sp. n., a Sporozoan Parasite of Blattella germanica: HOWARD CRAWLEY, Wyncote, Pa.

The parasite lives in the Malpighian tubules of the host. It originates as a

minute cell with a few nuclei. There is no definite body form. Development follows the neosporidian type; *i. e.*, nuclear multiplication and spore formation proceed *pari passu* with vegetative growth. There are two developmental cycles, resulting in the production of 'round bodies' and of spores. The 'round bodies' are 1.5 to 2 microns in diameter and contain a very irregularly shaped nucleus. The spores are ellipsoidal, 5 microns long and contain a round, oval or dumb-bell shaped nucleus. The parasite occurs in enormous numbers, but does not appear to exert a deleterious influence on the host.

Descriptions of a New Genus of Tanaidæ and a New Species of Tanais, both from Monterey Bay, California: Harriet Richardson, Smithsonian Institution.

Isopods from the Alaska Salmon Investigation: Harriet Richardson, Smithsonian Institution.

An Unnoticed Organ of the Sand-dollar, Echinarachnius parma: Emily Ray Gregory, Wells College.

A study of the morphology of the sand-dollar has shown the presence of a blind-ending diverticulum of the intestine which passes around the body-cavity, giving off branches on the outer side. In the young animal it is frequently distended with sand, but generally only a few grains of sand are found in it in the adult. The organ appears to be of most importance to the young animal, but whether its chief value is in removing sand from the intestine at this time or in carrying it to the different parts of the body cavity, has not been determined.

Physiological and Morphological Changes during 860 Generations of Oxytricha fallax: Lorande Loss Woodruff, Columbia University.

A culture of *Oxytricha fallax* was carried on from October, 1901, to its death in July, 1903, at the 860th generation. A record of the daily rate of division of the four lines of the culture was kept, and showed that the organism, when subjected to a uniform diet of hay-infusion, passes through marked periods of greater and less dividing activity. The first period of great loss of vitality occurred at about the 230th generation and the culture was on the verge of extinction, when it was 'rejuvenated' by the use of extract of beef. The second depression-period resulted in the death of the culture. A study of some two hundred permanent preparations of individuals showed that morphological changes occur during the life-cycle. A vacuolization of the cytoplasm appears first, and then distortion and fragmentation of the macronucleus, and reduplication of the micronuclei beyond the normal number when the vitality is at the lowest ebb. A similar study was made on four other cultures of hypotrichous ciliata and the results compared.

The Groups and Distribution of the North American Species of Diaptomus: C. Dwight Marsh, Ripon College.

Diaptomus is a genus of considerable interest, as it forms the greater part of the plankton that is available for food for fish. It is assumed that the genus is derived from marine ancestors, but it has no very close relatives. Thus far no attempt has been made even to arrange the American members of the genus in groups. A study of the distribution of the species with our present knowledge throws some light on the probable phylogeny of the group. There are now known thirty species. The distribution is in general one of latitude, with the greatest number of species in the mountain region of the west. A study of the distribution, with a comparison of structural characters, leads to a grouping of the species under four heads, the *tenuicaudatus* group, probably, being the

most primitive. The most important factors in the development of the various forms are temperature and isolation.

A Preliminary Note on the Snake's Tongue: EDITH M. BRACE, Western Maryland College.

The chief function of the snake's tongue seems to be connected with a sense of feeling that does not require the stimulus of contact, and may be a finer development of the sense that enables some people to avoid obstacles in the dark without touching them. The bifid tip and the numerous folds that lie behind the forking of the tongue serve to greatly increase the surface exposure. Beneath the epidermis and extending out into the folds there is a deep nerve plexus composed of multipolar cells whose ends are frayed out into extremely fine fibrils that interlace in every direction. From this plexus nerve fibers extend out between the cells of the epidermis.

C. JUDSON HERRICK,
Secretary.

DENISON UNIVERSITY.

SCIENTIFIC JOURNALS AND ARTICLES.

Palæontologia Universalis.—The third fasciculus of this important republication of old or obscure species of fossil organisms has arrived. These three parts of 75 species, figured and described on 161 sheets. This completes the first annual subscription, which is eight dollars. The first fasciculus of the second series will soon appear, and subscriptions should be sent to G. E. Stechert and Co., 129–133 West 20th Street, New York City. The editorial work is in the hands of D.-P. Œhlert, of Laval, France, secretary to the International Commission appointed by the International Geological Congress, at its eight meeting.

CHARLES SCHUCHERT.

THE contents of *The Journal of Comparative Neurology and Psychology*, for January, is as follows:

'On the Areas of the Axis Cylinder and Medullary Sheath as seen in Cross Sections of the Spinal Nerves of Vertebrates.' By Henry H. Donaldson and G. W. Hoke.

'On the Number and Relations of the Ganglion Cells and Medullated Nerve Fibers in the Spinal Nerves of Frogs of Different Ages.' By Irving Hardesty.

Editorial: 'Psychology and Neurology,' 'The International Commission on Brain Research.'

Literary Notices.

SOCIETIES AND ACADEMIES.

THE NEW YORK SECTION OF THE AMERICAN CHEMICAL SOCIETY.

THE New York Section of the American Chemical Society held its fourth regular meeting of the season at the Chemists' Club, Friday evening, January 6. The following papers were presented before the section:

The Application of Bismuth Ammonium Molybdate to Gravimetric Analysis: F. V. D. CRUSER and E. H. MILLER.

Portions of a standardized bismuth nitrate solution were precipitated by acid ammonium molybdate, under varying conditions. In order to get the solution barely acid, the use of congo red was found to be preferable to methyl orange. In washing the precipitate of bismuth ammonium molybdate, ammonium nitrate gave better results than ammonium sulphate. It was found that bismuth may be determined correctly by the ignition of bismuth ammonium molybdate to $Bi_2O_3 : 4MoO_3$, when the temperature of ignition is kept below a dull red heat, and that this method gives as good results as those obtained by the reduction and re-oxidation of the molybdium by potassium permanganate.

In determining bismuth by the evaporation of a nitric acid solution of bismuth nitrate, the operation must be conducted in porcelain, otherwise some bismuth trioxide is reduced by unburned gases passing through the platinum.

Recent Progress in the Chemical Department of the Geological Survey: F. W. CLARKE.

The Work of the Bureau of Standards: W. A. NOYES.

The work of the National Bureau of Standards is organized under three divisions and the first two of these divisions are subdivided into six sections each. The bureau is, first of

all, custodian of the legal standards of weights and measures for the United States, these being, in accordance with an act of Congress passed in 1893, a standard meter and a standard kilogram. In addition to the verification of weights and measures for state and United States officials and for private parties, a large amount of testing of thermometers, of pressure, gas and air meters, of electrical instruments for measuring resistances and other electrical quantities, and of electric lamps, is done. In connection with this work many researches are necessary, and the most important of those now in progress pertain to methods of measuring high and low temperatures, the development of standard sources of monochromatic light for use with the interferometer, the study of polarimeters with reference to their use in examination of sugars imported into the United States, the study of the Clark and Weston cells as standards of electromotive force, the study of the silver voltameter and electro-dynamometer for an absolute measurement of electrical currents, the measurements of inductance and capacity in their bearing upon the measurement of alternating currents, and the development of an integrating photometer for the measurement of mean spherical illumination by electric lamps. The chemical division expects to take up the subjects of standards of purity for chemical reagents and of standard methods of technical analysis.

Last Year's Work and Future Plans of the Bureau of Chemistry: H. W. Wiley.

The lines of investigation relating to problems connected with the applications of chemistry to agriculture were pursued with little change during the year ending June 30, 1904. In order to secure economy as well as efficiency in this work an endeavor has been made for many years to collaborate with other scientific investigators in the problems which are under consideration. This has been particularly true in connection with investigations undertaken to determine the effect of environment upon chemical composition in sugar-producing plants. This work was confined for a long time to the evolution of a sorghum plant containing a high content of sugar and a low content of melassigenic substances. Later the same lines of investigations were applied to the sugar beet in a general way.

For lack of funds similar experiments authorized by Congress in the study of the effect of environment upon the composition of the cereal grains have not been pushed as vigorously as could be hoped. Nevertheless, numerous comparative determinations have been made of the effect of the environment on the protein content of wheat. These data, which have been collected over a period of several years, have for their chief purpose to indicate the general character of the study necessary to determine more accurately those conditions which affect so seriously the composition of the wheat kernel. The purposes which should be kept in view in the growth of wheat include those relating to the possibilities of panification. While it is generally true in the case of wheat that the gluten content increases *pari passu* with the content of protein, such is not always the case. The causes which disturb the equilibrium existing between the gluten and the protein are worthy of serious and careful study. The ultimate object of the studies which the bureau has now in hand is to indicate the conditions which are favorable to the production of a grain of any desired quality.

During the past year the demand which has been made upon the Bureau of Chemistry for information in regard to technical problems of a chemical character relating to the production of paper and leather has been very great. The diminishing supplies of raw material in the production of paper and the consequent increase in price have made the agricultural problem of the production of this material one of great importance. Forests suitable for the production of paper pulp are rapidly disappearing and the deficiency of the material which arises from this cause must be supplied from other agricultural sources. The fibers of many plants which have heretofore been used only as waste material offer promising sources of supply. Among these may be mentioned the Indian corn stalk, the cotton stalk, and the bagasse

resulting from the manufacture of sugar and syrup from sugar cane. The importance of the supply of tanning materials and of the study of leathers in regard to strength, appearance and durability is also growing, and constant demands are made upon the Bureau of Chemistry for information on these points.

Most important of the new work which was undertaken during the past year is the inspection of imported food products. Problems connected with the use of artificial colors, glucoses and preservatives have also been studied with a view of making the law more efficient. In the food laboratory important studies have been made during the year on the composition of tropical fruits and fruit products.

In the road material laboratory extensive tests have been made of all the materials used in road construction, both physical and chemical. The relations of colloidal structure to plasticity have been made the subject of especial research, the results of which were communicated to the society at the Philadelphia meeting by Dr. Cushman.

In the insecticide and agricultural water laboratory investigations of insecticides and fungicides, in connection with the Division of Entomology and the Bureau of Plant Industry, have been continued and an elaborate investigation of the character of mineral waters offered for sale has been partially completed. The work on the arsenic content of papers and fabrics sold on the American market has been completed and published as Bulletin No. 86.

F. H. POUGH,
Secretary.

DISCUSSION AND CORRESPONDENCE.

'BERYLLIUM' OR 'GLUCINUM.'

THERE is apparently little difference of opinion between Dr. Howe and myself as to the facts upon which a claim to priority of 'beryllium' over 'glucinum' as a name for the element under discussion is based, and I am willing to leave the interpretation of those facts to chemists at large.

It has, I think, been supposed, by those of the profession who have not personally looked into the matter, that the oxide was named 'glucine' by Vauquelin himself. I understand that Dr. Howe in his reply to me in SCIENCE, for January 6, admits that Vauquelin did not name the element or the oxide; that he in fact would probably have liked to name it 'beryllia,' really adopting glucine in his fourth publication under virtual protest, and that the clause 'la terre du Béril' used by Vauquelin in place of a name was literally translated into German as 'Berylerde,' becoming a definite name, used to this day, before Vauquelin consented to the use of 'glucine.' I think also that he will not question the fact that when it came to the actual use of the terms themselves Wohler separated and described 'beryllium'* before Bussy prepared 'glucinium'† although they were but a few weeks apart. With this summary I am perfectly willing to leave the question of priority to the 'ninety and nine' who are already using the more preferable term.

As to usage, it is quite evident that Dr. Howe's closing remarks are intended as a pleasantry, as I hardly think he wishes to give the impression that kalzium, kolumbium, etc., are the custom in German chemical literature. He does not question that the major part of the literature is German nor that the Germans, Swedes, Danes, Russians, Dutch and Italians use 'beryllium' exclusively. Next to the Germans the French have the most articles to their credit and use 'glucinium' exclusively, but the impression which Dr. Howe seems to wish to convey, that this is the customary term in England and America, is not correct. He made a lucky find in the index of the *Journal of the Chemical Society* (London) for 1903, which does read 'Beryllium, see Glucinum,' for some unknown reason, for the one abstract to which it refers uses 'beryllium' solely both in title and in subject matter, and 'glucinum' does not appear in this journal in index or abstracts on the subject for several years previously, although the abstracts are frequently from the French. This journal apparently leaves the matter to the wishes of the author, for Pollock in 1904 uses again 'glucinum.' For at least five years

* *Ann. der Phys.*, 13, 577.

† *Journal de chim. medical*, 4, 453.

the term 'beryllium' has been used exclusively in the index of the *Journal of the Society of Chemical Industry* and, so far as I have noticed, in the subject matter as well. On the other hand, the *Chemical News* uses the two words interchangeably in its articles, abstracts and index, part of its articles being indexed under one head and part under the other, and, unfortunately, without any attempt at cross reference. In America only one original article has appeared on the subject in many years which has used 'glucinum.' The *American Chemical Journal* has used 'beryllium.' The *American Journal of Arts and Sciences* for some years has used 'beryllium' and it is here that some of the best articles have appeared. The *Journal of Physical Chemistry* uses 'beryllium.' The *Journal of the American Chemical Society* has allowed its contributors to choose, and one article and two abstracts have appeared on 'glucinum' since its publication.

To play on Dr. Howe's own words, I think that with American, English, German, Swedish, Danish, Dutch, Russian, Italian, etc., journals and chemists using 'beryllium,' we can afford to let the French cling to 'glucinium' (not 'glucinum') a little while longer.

It is true that the committee appointed by the American Association on the Spelling and Pronunciation of Chemical Terms did recommend 'glucinum,' and so far as I can find its members are about the only American chemists loyal to the term. I think it highly unfortunate that their recommendations as to spelling and pronunciation have not been more generally adopted in our chemical literature and language, but it is true they have not and in regard to 'glucinum' it is my humble opinion that they were wrong.

Charles Lathrop Parsons.
New Hampshire College,
January 23, 1905.

The English Sparrow as Embryological Material.

Doubtless many readers of Science who conduct courses in vertebrate embryology, in which the chick is one of the forms studied, have spent laborious hours in mounting serial sections of embryos of from five to eight days' development. The chick embryo of this age has reached so considerable a size that, even though the sections be cut comparatively thick, a complete series will fill a large number of slides. Of course type sections may be selected, and slide-room thus saved, but it takes nearly as long to prepare such a selected series as it does to mount the entire series.

A convenient substitute for the later chick embryos may be found in the ubiquitous and generally disliked English sparrow. There are probably few localities where the nests of this little pest may not be found; frequently they are so numerous that a large number of eggs may be obtained without difficulty.

So far as size is concerned, the sparrow, even at the time of hatching, is small enough to section without especial difficulty, and at the stage corresponding to the eight-day chick it is so small that a complete series may be mounted on a comparatively small number of slides.

Many teachers have probably made use of this source of supply of material to illustrate some of the phases in avian development that are usually read about in the text-books without being studied in the laboratory, but there may be some who have not thought of this method of procuring material and at the same time of helping to reduce the English sparrow population.

The idea is not original with the writer, but he is sure that it is not patented.

Albert M. Reese.
Syracuse University.

Deluc versus de Saussure.

To the Editor of Science: In his letter of December 29 (Science, 525, p. 111), Dr. Eastman, returning to the question as to whom priority in the use of the term 'geology' properly belongs, says:

> I am unable to see why Von Zittel was not scrupulously exact in his handling of facts when crediting Deluc with prior use of the term geology as compared with De Saussure.

His letter bears internal evidence that, like me, Dr. Eastman has been unable to obtain the 1778 edition of Deluc's letters, which alone

can be assumed to prove that priority. If this is the case, he is not justified in assuming that his quotation from the edition of 1779 is identical in wording with the original statement in the preface of 1778. This quotation is: 'L'usage ordinaire a consacré le premier des ces mots (cosmologie) dans le sens où je l'emploie.'

Geikie's statement with regard to the 1778 edition is: "The proper word he admits should have been geology, but he could not venture to adopt it because it was not a word in use."

Eastman, assuming that the statement in the second edition was word for word the same as that in the first edition, says that Geikie's rendering is not justified.

I reply that his assumption is unfounded, for so prolific a writer would be more likely than not to vary the wording of his phrases on a second writing. But even if the assumption were correct, Eastman's own rendering, 'the word cosmology is more generally used in an equivalent sense' is as free in one direction as Geikie's in another.

Entirely aside from this question, which is somewhat on the hair-splitting order, it is to be observed that my statement was, that De Saussure was the first geologist (in the modern sense, as Dr. Eastman kindly added for me) to use the word geology in speaking of his science. There is no question that De Saussure was such a geologist. Let us see, then, what authorities like Von Zittel and Geikie think of Deluc in this regard.

Von Zittel qualifies him as a remarkably busy but flighty observer, and a fantastic scribbler whose publications have, for the most part, fallen into deserved oblivion. His use of the term geology he says is first suggested in the preface to a volume containing fourteen letters addressed to Queen Charlotte of England, whom he served for many years as reader and traveling companion. This preface, he says, makes the pompous announcement that the book will contain the groundwork of a cosmology or earth history, but when examined the letters are found to be mostly filled with long-winded descriptions of the lands and peoples visited and very little of what the preface promises.

Geikie classes him with Richardson, the believer in fossiliferous basalt, Kirwan and others of that ilk, and says:

> But though these men wielded great influence in their day their writings have fallen into deserved oblivion. They are never read save by the curious student who has leisure and inclination to dig among the cemeteries of geological literature.

S. F. EMMONS.

SPECIAL ARTICLES.

NOTE ON THE VARIATION OF THE SIZES OF NUCLEI WITH THE INTENSITY OF THE IONIZATION.

1. I shall use the word fog-limit, to denote the difference (δp) of pressure between the outside (constant pressure) and the inside of the fog-chamber, to which sudden exhaustion must be carried in order that condensation may just occur in dust-free air saturated with moisture. It is obvious that if the fog-limit is to be used as a criterion, the result depends in all cases (cæt. par.) on the particular type of fog-chamber used and all statements are to refer to a given type.

2. Nuclei of any size may be produced in dust-free moist air by varying the time and the intensity of the exposure to X-ray or other similar radiation. A particular fog-limit and hence a particular size of nucleus is reached for each case until the fog-limit vanishes. Thus in my experiments for

Dust-free air (radium at infinity)				$\delta p = 24.5$
Radium (10,000 ×, in thin sealed glass tube)				
	at 200 cm. from fog-chamber,			21.5
	at 100 cm. "	"		20 8
	at 45 cm. "	"		20.2
Radium, do., within the fog-chamber				19
X-ray bulb				
at 35 cm.	from fog-chamber,	exposure	2 min.	$\delta p = 19$
at 10 cm.	"	"	2 "	18
at 10 cm.	"	"	4 "	17
at 2 cm.	"	"	2 "	15.5
at 2 cm.	"	"	4 "	10
at 2 cm.	"	"	10 "	vanishing
at 2 cm.	(stronger radiation)	"	5 "	5
at 2 cm.	(still stronger radiation)	"	5 "	below 4

To these may be added the fog-limits corresponding to the more gradual decay of excited radio-activity (radium 10,000 ×, in thin hermetically sealed aluminum tube placed for 15 or 30 minutes within the fog-chamber).

Radium present in fog-chamber						$\delta p = 18.5$
Radium removed.	3.5 hours after removal,					21
"	"	21	"	"	"	22
"	"	29	"	"	"	23

On leaving the fog-chamber for hours without interference, the fog-limit for the excited activity was found to be lower, the coronas (cæt. par.) larger than if but a few minutes elapse between the condensations. Thus it takes time for the induced activity to saturate the air within the fog-chamber with nuclei, and more time as its activity is weaker. Persistence in case of the larger (X-ray) nuclei must be reckoned in hours.

A little induced activity was obtained through the hermetically sealed glass tube (walls say .5 millimeter thick) vanishing completely in about fifteen minutes, to the fog-limit of dust-free air. The same radium in the hermetically sealed aluminum tube (walls say .1 millimeter thick) left an excited activity behind in the fog-chamber, vanishing in about forty hours gradually to the fog-limit of dust-free air. It seems, therefore, as if something besides beta and gamma rays passed through these relatively thick tubes. Leaving this for further examination* I need merely instance here the adaptability and sensitiveness of the condensation method for the present purposes, where, moreover, the coronas will indicate the numbers of nuclei produced under any given conditions.

2. The general facts of the preceding paragraph are inferred objectively if an X-ray bulb is placed near one end of a long condensation chamber of waxed wood and the effect of sudden exhaustion viewed broadside through plate glass windows.† The coronas obtained after short exposure are all roundish, but taper in diameter from a large size near the bulb to a vanishing diameter (apex) near the middle of the chamber, with all intermediate gradations of aperture in corresponding intermediate positions. All lie within two oblique lines symmetrically inclined to the horizontal axis and meeting near the middle. The pressure difference used is thus more and more in excess of the fog-limit as the line of sight is nearer the bulb. Beyond the apex, the pressure difference used is below the fog-limit. The number of nuclei within the given range of condensation, *i. e.*, above a certain lower limit of diameter, increases with the intensity of the ionization. Smaller nuclei occur throughout the chamber and particularly within the reentrant region left blank after condensation.

3. If the number of nuclei (n per cu. cm.) is mapped out in relation to the corresponding pressure difference, δp, the initial slopes of the curves obtained are steeper as the fog-limit is lower. Thus per increment of δp of one cm. of mercury above the fog-limit of the ionized medium, and decidedly below the fog-limit of dust-free air, I observed with

Radium in sealed aluminum tube within fog-chamber,	$\delta n = 12{,}000$
Radium in sealed glass tube within fog-chamber.	6,000
Radium in sealed glass tube, 45 cm. from fog-chamber, outside	4,000
Do., 200 cm. from fog-chamber	1,000
Dust-free air (δp above 24.5 cm., radium at infinity)	4,000

Hence, effectively, the gradation of nuclei is more even, finer, *i. e.*, with fewer gaps, as the fog-limit is low and the maximum size of nucleus larger, while for sparse distributions the steps from one nucleus to the next in the order of average size are relatively large. For a different medium, dust-free air, for instance, the gradation is characteristically different.

Carl Barus.

Brown University, R. I.

* An important question is here confronted: Can an induced activity having any period of decay (within limits) be produced by successive filtering of the contents of the sealed tube containing radium, through walls of different thickness of density. In such a case the induced activity (supposing that no emanation escapes) would be a kind of phosphorescence.

† *Am. Journal*, Vol. 19, February, p. 175, 1905.

CURRENT NOTES ON METEOROLOGY.

LONDON FOG INQUIRY, 1901–3.

The 'Report of the Meteorological Council upon an Inquiry into the Occurrence and Distribution of Fogs in the London Area, during the Winters of 1901–2 and 1902–3' has been issued, and is summarized in *Nature* for January 12, 1905. The investigation was carried on with the aid of the Metropolitan

Fire Brigade, at thirty of whose stations daily temperature observations were made at fixed hours. The majority of the fogs are found to be due to radiation during calm, clear nights. Others are due to the passage of warm air over a cooled surface, and a third group is identified as 'cloud' fog. Some fogs could not be included in any of these categories. These fogs were accumulations of combustion products in an almost calm atmosphere, and were termed 'smoke' fogs. A fog scale, based on the extent to which traffic is impeded by land, river and sea, has been established as a result of this inquiry. As a first step in the direction of greater precision in fog forecasts, a night service at the Meteorological Office is recommended. Forecasts issued at 5 A.M. would have a much greater chance of being verified than is the case with those now issued at 6 P.M., for fogs are chiefly caused by nocturnal radiation. Radiation depends largely on the state of the sky, and an observation of the state of the sky in the early morning would make it possible to give several hours' warning. The present forecasts rarely, if ever, contain any indication of the intensity of the fog to be expected. A detailed study of the distribution of temperature within the London area during fogs shows that the thickest fog is usually to be found in the coldest region.

MOSSES, TREES AND POINTS OF THE COMPASS.

A RECENT number of *Ciel et Terre* (December 16, 1904) contains a note on the orientation of moss growths on trees. It has been stated that mosses grow so much more frequently on the north sides of trees that a traveler who has lost his way in a forest can by this means determine the points of the compass. Lately, further investigation of this matter shows that the mosses grow by preference on the sides of the trees which, for one reason or another, are least likely to lose their moisture. On horizontal branches, the mosses usually grow on the upper side, because the water remains there most readily. The bases of the trunks are more moss-covered because they receive a larger quantity of water. The unequal distribution of light also plays a part.

MONTHLY WEATHER REVIEW.

THE October, 1904, *Monthly Weather Review* (dated December 22) contains the following original articles and notes: 'Studies of Raindrops and Raindrop Phenomena,' by W. A. Bentley, illustrated by photographic reproductions; 'The Advancement of Meteorology,' by T. H. Davis; 'Thunderstorms at Tampa, Fla.,' by J. Bily, Jr.; 'Mount Tsukuba Meteorological Observatory,' by S. T. Tamura; 'September Floods in the Southwest'; 'Royal Meteorological Society'; 'Long-Range Forecasts,' by H. B. Wren; 'Seasonal Rainfall Régimes in the United States,' by V. Raulin; 'Tropical Storm of October 10–20, 1900'; 'The Dechevrens Anemometer: Cold Waves.'

NOTES.

THE *Bulletin* of the Philippine Weather Bureau for July, 1904, just received, gives details of a remarkable rainfall which occurred on the eleventh to the fifteenth of that month. Between 8 A.M. of the twelfth and 11 A.M of the thirteenth the total fall at the Manila Observatory was 17.19 inches, a quantity much greater than the normal rainfall for July (14.89 inches), which is also the normal monthly maximum for the year. Three half-tone views show the character of the inundations in the city of Manila.

R. DEC. WARD.

SCIENTIFIC NOTES AND NEWS.

AT the meeting of the Society of American Bacteriologists, held in Philadelphia on December 28, 1904, the following officers were elected: *President,* Professor E. O. Jordan; *Vice-President,* Professor S. C. Prescott; *Secretary* and *Treasurer,* Professor E. P. Gorham; *Council,* Professor F. G. Novy, Dr. Erwin F. Smith, Professor F. D. Chester, Dr. J. J. Kinyoun; *Delegate to the Council of the American Association for the Advancement of Science,* Professor W. H. Welch.

OFFICERS for the Society for the Promotion of Agricultural Science have been elected as follows: *President,* Dr. H. P. Armsby, State College, Pa.; *Secretary* and *Treasurer,* Professor F. Wm. Rane, New Hampshire College, Durham, N. H.; *Executive Committee,* Dr. J.

C. Arthur, Purdue University, Lafayette, Ind.; Dr. W. J. Beal, Agricultural College, Mich.; Professor F. M. Webster, University of Illinois, Urbana, Ill.

The following eminent foreign physiologists have been elected honorary members of the American Physiological Society: Th. W. Engelmann, professor of physiology in the University of Berlin; A. Dastre, professor of physiology at the Sorbonne, Paris; J. N. Langley, professor of physiology, Cambridge University; C. S. Sherrington, professor of physiology, University of Liverpool; Fr. Hofmeister, professor of physiological chemistry at the University of Strasburg; J. P. Pawlow, director of the Physiological Laboratory at the Imperial Institute for Experimental Medicine, St. Petersburg.

M. L. Troost, honorary professor of chemistry at the University of Paris, is this year president of the Academy of Sciences in succession to M. E. L. Mascart, professor of physics at the Collège de France.

At the recent annual meeting of the Torrey Botanical Club Judge Addison Brown resigned the presidency after fifteen years of service. Dr. H. H. Rusby, of the College of Pharmacy, was elected as his successor.

A cablegram to the New York *Sun* states that Ambassador Choate on February 10 attended the annual meeting of the Royal Astronomical Society to receive the society's gold medal on behalf of Lewis Boss, director of the Dudley Observatory at Albany, N. Y. Professor Herbert Turner, who presided, paid a tribute to Professor Boss. He added that at present a feature of the world's astronomical research was the steady work done in the United States. It was a pleasure to the society for the third time in five years to recognize this work. Mr. Choate suitably acknowledged the gift on behalf of the recipient.

It is said that Professor Francis G. Peabody, Plummer professor of christian morals, has been selected by the University of Berlin to be Harvard's first lecturer under the arrangement recently entered into between Harvard and Berlin to exchange professors.

Mr. Robert T. Hill, accompanied by Dr. E. O. Hovey, of the American Museum of Natural History, and a corps of assistants, has left upon an expedition for the purpose of studying the geography and geology of the Western Sierra Madre of Mexico. The party expects to do valuable reconnaissance work in this interesting field in continuance of the investigations upon the mountains and deserts of the Southern Cordilleras, which Mr. Hill carried on for many years while associated with the Geological Survey, and of Professor Hovey's studies of volanic phenomena. The expedition is fully equipped for topographic, photographic and geologic work. It is financed by an anonymous New York capitalist.

Mr. Walter H. Gilbert, chief clerk in the president's office of Columbia University, has been appointed assistant secretary of the Carnegie Institution.

Dr. W. M. Wheeler, curator of invertebrate zoology at the American Museum of Natural History, will give, at Columbia University, during March, a series of lectures on the social insects—wasps, bees and ants.

Sir William Thiselton-Dyer, director of the Royal Botanic Gardens, at Kew, took the chair at the opening lecture of the year, delivered, at the West India Committee-rooms, London, on January 25, by Mr. W. G. Freeman, superintendent of the Colonial Economic Collections at the Imperial Institute, on 'The West Indian Fruit Industry.'

We learn from *The British Medical Journal* that the Danish government has issued a stamp bearing the head of the late Professor Finsen with the object of placing within reach of the poorer classes a means of subscribing to the national monument by which it is proposed to commemorate the work of the Danish investigator. On the occasion of the Christmas and New Year holidays the Danish postmaster-general also issued four million illustrated postcards. The profits on the sale of these postcards are to form the basis of a fund for the erection of a sanatorium for indigent consumptives.

DR. LUDWIG VON TETMAJER, professor of technical mechanics in the Technical Institute of Vienna, died on January 31.

DR. ALPHEUS S. PACKARD, professor of zoology and geology at Brown University, died on February 14, at the age of sixty-six years.

FIVE hundred dollars will be awarded by the College of Physicians of Philadelphia to the author of the best essay submitted in competition on or before March 1, 1906, on 'The Clinical and Pathological Diagnosis of Sarcoma.' Further information may be obtained by addressing Dr. Francis R. Packard, College of Physicians, Philadelphia.

THE Colorado Experiment Station has recently purchased additional land, to extend its farm facilities and to use for the horse-breeding experiments to be carried on with the cooperation of the U. S. Department of Agriculture. The short course in agriculture at the college has proved successful, over one hundred students being in attendance. It lasted for two weeks.

THE case brought by Kansas against Colorado is now being heard before the U. S. Supreme Court through a commissioner. The case involves the situation where the customs applicable to one set of conditions have been found to be inapplicable to those of another, for the riparian doctrine of England and the East is in conflict with the necessity to divert water for irrigation.

THE state of Vermont, following the state of Connecticut, has passed an act making it obligatory to examine each year the eyes and ears of public school children.

The British Medical Journal gives further details in regard to the celebration of the hundreth birthday of Senor Manuel Garcia, which occurs on March 17. The anniversary is to be made the occasion of a great demonstration in his honor by laryngologists of every nationality, who will at the same time celebrate the jubilee of their specialty. The program, as far as at present arranged, is as follows: At midday a ceremonial meeting will be held at the rooms of the Royal Medico-Chirurgical Society, Hanover Square. The Spanish ambassador will attend to congratulate the illustrious centenarian in the name of the government of his native country, and addresses will be presented by the Royal Society, before which Senor Garcia read his paper entitled 'Physiological Observations on the Human Voice' just fifty years ago; by delegates of the Berlin, South German, French, Dutch and Belgian Laryngological Societies; by musical societies and by old pupils of the famous *maestro*. In order not to overtax the strength of Senor Garcia, the addresses will for the most part be only formally presented, and the whole duration of the proceedings will not exceed one hour. The meeting will conclude with the presentation to Senor Garcia of his portrait painted by Mr. John Sargent, R.A., at the request of admirers throughout the world, together with an album containing the names of the subscribers. In the afternoon a scientific meeting will be held in the same place for the purpose of giving foreign specialists an opportunity of seeing the methods of work and results of their British brethren. In the evening there will be a dinner, probably at the Hotel Cecil, at which ladies will be present, and it is expected that Senor Garcia will make a speech. Notwithstanding his great age, he is still fairly vigorous in body, and he was able to attend the annual dinner of the Laryngological Society on January 13. His mental powers are absolutely undimmed by age.

IN Massachusetts numerous spring waters have been developed in the vicinity of large cities. The population of the state is largely concentrated in towns, and in all the larger municipalities water systems are maintained. Lake, stream and spring supplies are all utilized, although where the first two are used great precautions are necessary to prevent pollution. In the rural districts of the western or more hilly half of the state springs constitute in many instances the commonest source of water supply, but their use is by no means confined to that region. In fact, because of the absence of other satisfactory supplies, they are often of far greater economic importance in the eastern part of the state, where many of the waters are used in bever-

ages, or bottled or sold in bulk as table waters. It is because of the economic value of the individual springs that the eastern counties are so well represented in the spring records kept by the United States Geological Survey and published in Water Supply and Irrigation Paper No. 102, entitled 'Contributions to the Hydrology of Eastern United States, 1903.' Analyses are given of spring waters at South Wellfleet, Danvers, Arlington, Chelmsford, Coldspring, Framingham, Quincy, Sharon, Hanson, Hingham, Marshfield, Norwell, Scituate, Whitman and Hubbardston. Many interesting details are also added regarding the characteristics of these various waters. Owing to the cooperation of Mr. F. A. Champlin, a driller, the records of Massachusetts wells are also unusually complete. It is hoped that other drillers in this state and other states may care to keep a record of the wells they drill, and be willing to supply the survey with data showing the date on which each well was drilled, the situation of the well, how the water was obtained, the depth of the open portion of the well, the depth of the drilled portion, the total depth of the well, the depth to water, the depth to rock, the supply per minute, the use to which the water is put, and the cost of the work.

UNIVERSITY AND EDUCATIONAL NEWS.

In his last report President Eliot recommends the collection of $2,500,000 as an endowment for the college of Harvard University, and it is said that the alumni are making efforts to collect this sum before the next commencement day. The class of 1880 expects to contribute $100,000 on the occasion of its twenty-fifth anniversary.

Mr. Andrew Carnegie has given to the Rensselaer Polytechnic Institute at Troy $125,000 toward rebuilding the main building which was burned last June. He has also given $100,000 to Tufts College for the erection of a library building.

The trustees of Stevens Institute of Technology in Hoboken have decided to proceed with the construction of the proposed Morton Memorial Chemical Laboratory as soon as possible. The sum of $91,000 has been raised and $4,000 is available in unpaid subscriptions. It had been planned to spend $100,000 for the building and site. The proposed building will contain a memorial room in which will be placed souvenirs of the late president and other members of the faculty who have died.

Columbia University has established a course in chemical engineering leading to the degree of chemical engineer. The university has received a gift of $10,000 to equip a laboratory of electro-chemistry.

Mr. Edward Whitley, of Trinity College, Oxford, has given £1,000 to the university towards the endowment of a chair of pathology.

The Johnston Scholarships, founded at the Johns Hopkins University by the late Mrs. Harriet Lane Johnston, in memory of her husband and two sons, have been awarded for the current academic year as follows: The Henry E. Johnston scholarship to Solomon Farley Acree, B.S. (Texas), Ph.D. (Chicago), in chemistry; the James Buchanan Johnston scholarship to Henry S. Conard, A.M. (Haverford), Ph.D., in botany; the Henry E. Johnston, Jr., scholarship to Isaac Woodbridge Riley, A.B., Ph.D. (Yale), in philosophy. The stipend of each of these scholarships is the income of $30,000. They are offered primarily to young men who have given evidence of the power of independent research, and the holders are expected to devote themselves to advanced study and to research in the Johns Hopkins University.

Mr. Omar Ray Gullion has resigned his position as assistant in physiology at the University of Missouri to accept an instructorship in pharmacology at Cornell University.

The University of Wisconsin will next year give instruction in meteorology under Mr. James L. Bartlett, observer at the University station of the U. S. Weather Bureau.

The new chairs of helminthology and protozoology at the London School of Tropical Medicine have been filled by the appointment of Mr. Robert Thomson Leiper to the former and Mr. W. S. Perrin to the latter.